METAL PROGRESS

SEPTEMBER 1940

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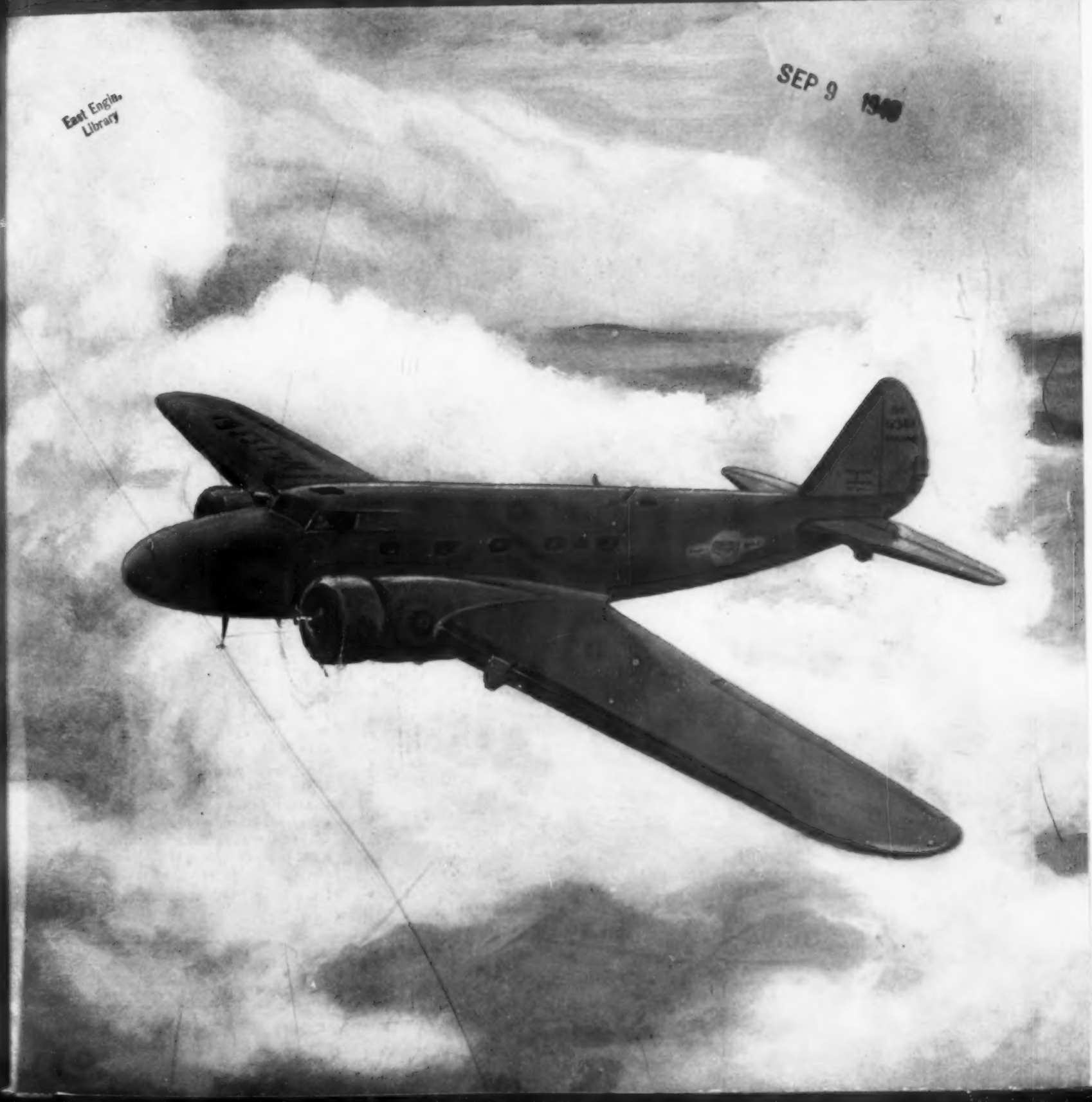

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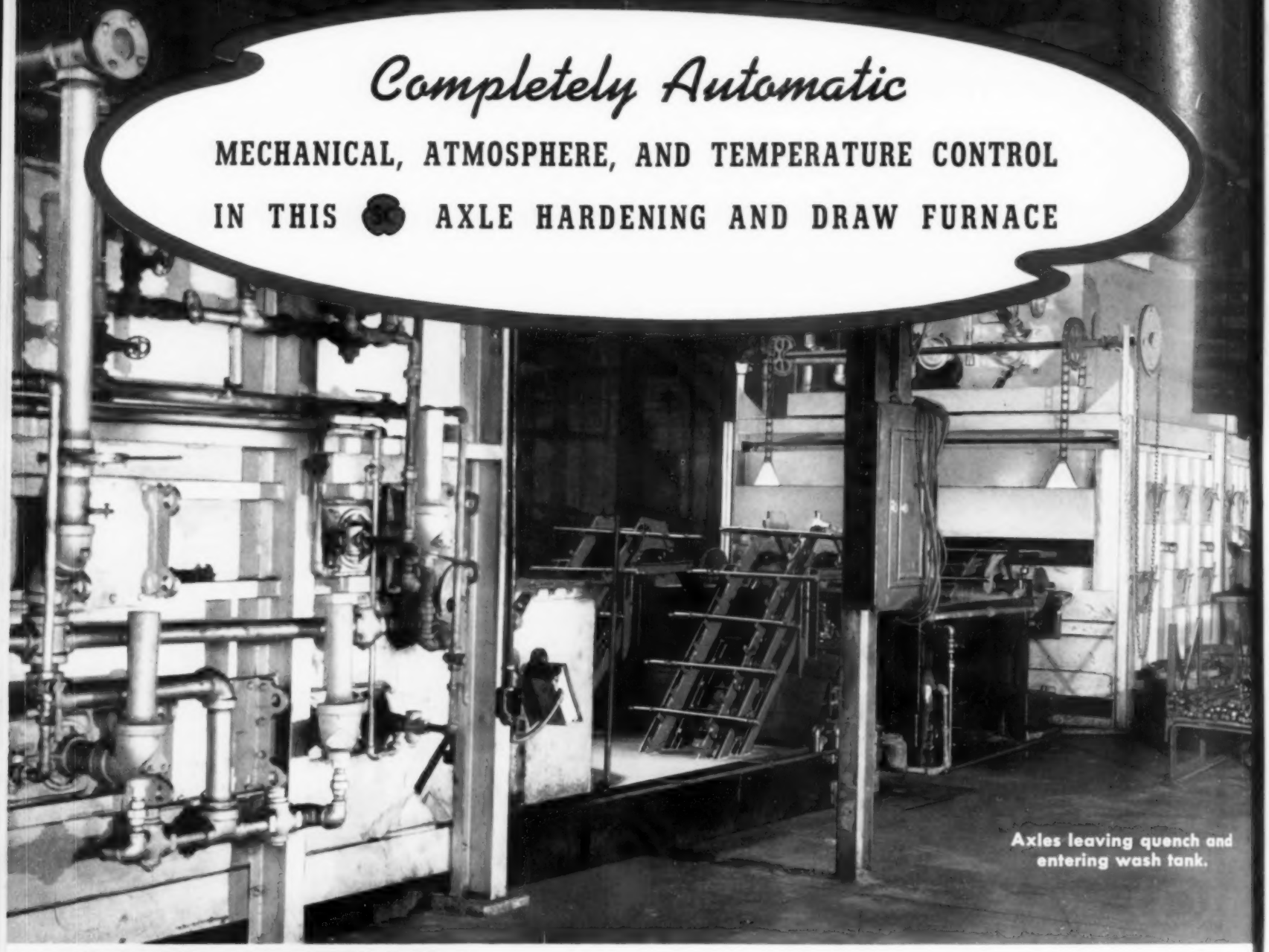
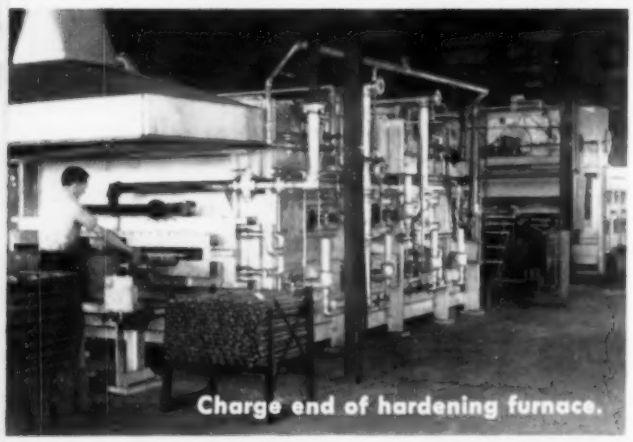
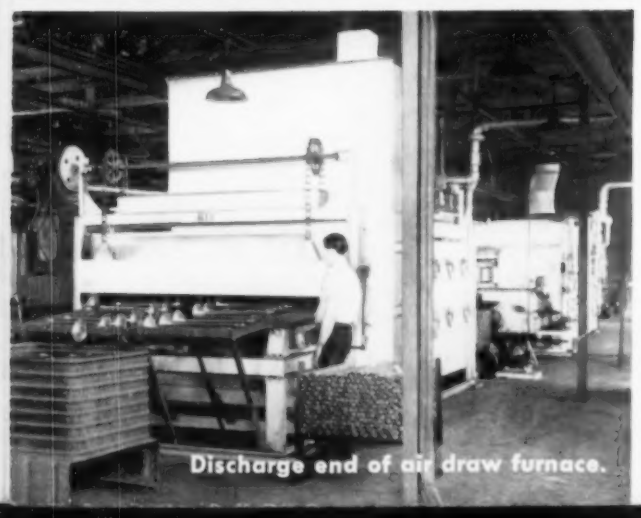


Axles leaving quench and entering wash tank.



Charge end of hardening furnace.



Discharge end of air draw furnace.

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NEW YORK WORLD'S FAIR

Metal Progress

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Practical Gas Carburizing 261
by John F. Wyzalek and M. H. Folkner

Critical Points by the Editor 269
Organize Munitions Research
Wanted: A Die Steel for Brass Casting
Metallurgy in Oil Field Machinery
Tool Joints Must Not Burst, Wear or "Fatigue"
Bessemer Flame Control
Soft Skin Is Retained Austenite

Burnie Lee Benbow 272
Another Biography of an Eminent Living Metallurgist

Spot Welding of Aluminum for Aircraft 274
by L. P. Wood; Abstract of "Welding in Aircraft Industry", *The Welding Journal*, July 1940, p. 476

Die Casting a Projector Frame 275
Pictorial Story, Photographed by Van Fisher

New Magnetic Alloy of Powdered Metal 284
by V. E. Legg and F. J. Given; Extracts from "Compressed Powdered Molybdenum Permalloy for High Quality Inductance Coils", *Bell System Technical Journal*, July 1940, p. 385

Sharp Transition From Brittle to Ductile in Hot Ingot Iron 287
by Matthew Charlton

Soft Soldering 290
by J. L. Miller; Abstract from *The Metal Industry*, Aug. 2, 1940, p. 82

Correspondence
No Mystery in Arc Welding, by A. F. Davis 291
Use of Clad Metals in Germany, by W. Rädeker 292
Converter Steel for Shrapnel Shells, by Albert M. Portevin 294
Mixture of Bakelite and Metal Powder for Mounting Microspecimens, by Norman J. Finsterwalder 294
Protective Coating Sprayed on Aluminum Castings, by R. M. Major 295
Another Ghost (Dodo Bird), by Henry Aughey 296
Energy Losses in Impact Testing, by N. Davidenkoff 297

Personal News, Largely Movements of A.S.M. Members .. 300

Biographical Notes and Portraits of Contributors 314

Literature Produced by Advertisers, Free to Readers .. 243-245

Index of Firms Which Are Advertising 346

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Practical Gas Carburizing

By John F. Wyzalek
Chief Metallurgist
Assisted by M. H. Folkner
Research Metallurgist
Hyatt Bearings Division, General Motors Corp.
Harrison, N. J.

An article on Carburizing Practice, treating especially of solid compounds and their relative adaptability, was published by Mr. Wyzalek in METAL PROGRESS *for February 1935. This is a good supplement, as it treats of gas carburizers rather than solid ones. It is adapted from a paper read before the New England Regional Meeting, ASM, Hartford, Conn., on May 17, 1940. It reviews an important process from its initial development in the laboratory to its successful commercial application, a process defined by the Metals Handbook as one whereby "carbon to be supplied to the steel is introduced to the work chamber, or retort, of the furnace in a gaseous state".*

GAS carburizing, although attracting much attention from production metallurgists in recent years, is a relatively old idea underlying scientific work dating as far back as the middle of the 19th century. However, it remained for FEDERICO GIOLITTI in the early 20th century to clarify the vague generalities and conflicting opinions surrounding previous work by conducting numerous brilliant experiments; he did much toward stimulating the development of this process on a practical basis. The scope and importance of his work may be more fully appreciated by referring to his book, "Cementation of Iron and Steel", translated from the Italian and published in the United States in 1915.

Commercial development over here had started ten years earlier. A patent for a rotary furnace, batch type, for gas carburizing was applied for on Feb. 4, 1905 by A. W. MACHLET, president of American Gas Furnace Co. of Elizabeth, N. J., and granted in 1906. The first commercial installations in this country were made during December 1906 and January 1907; they used city gas as a carburizing agent. The first large installation was made in 1909 by the Buick Motor Co. — ten rotary furnaces. It is interesting to note that some of the very first units were supplied with auxiliary equipment designed to produce the carburizing medium in gas generators, a necessity due to the unreliability of city gases as a carburizer when obtained in different localities. The gas generator used peat moss or charcoal since these were sulphur-free; the gas was passed through a scrubber and then through gasoline where it became enriched in hydrocarbons prior to entering the retort.

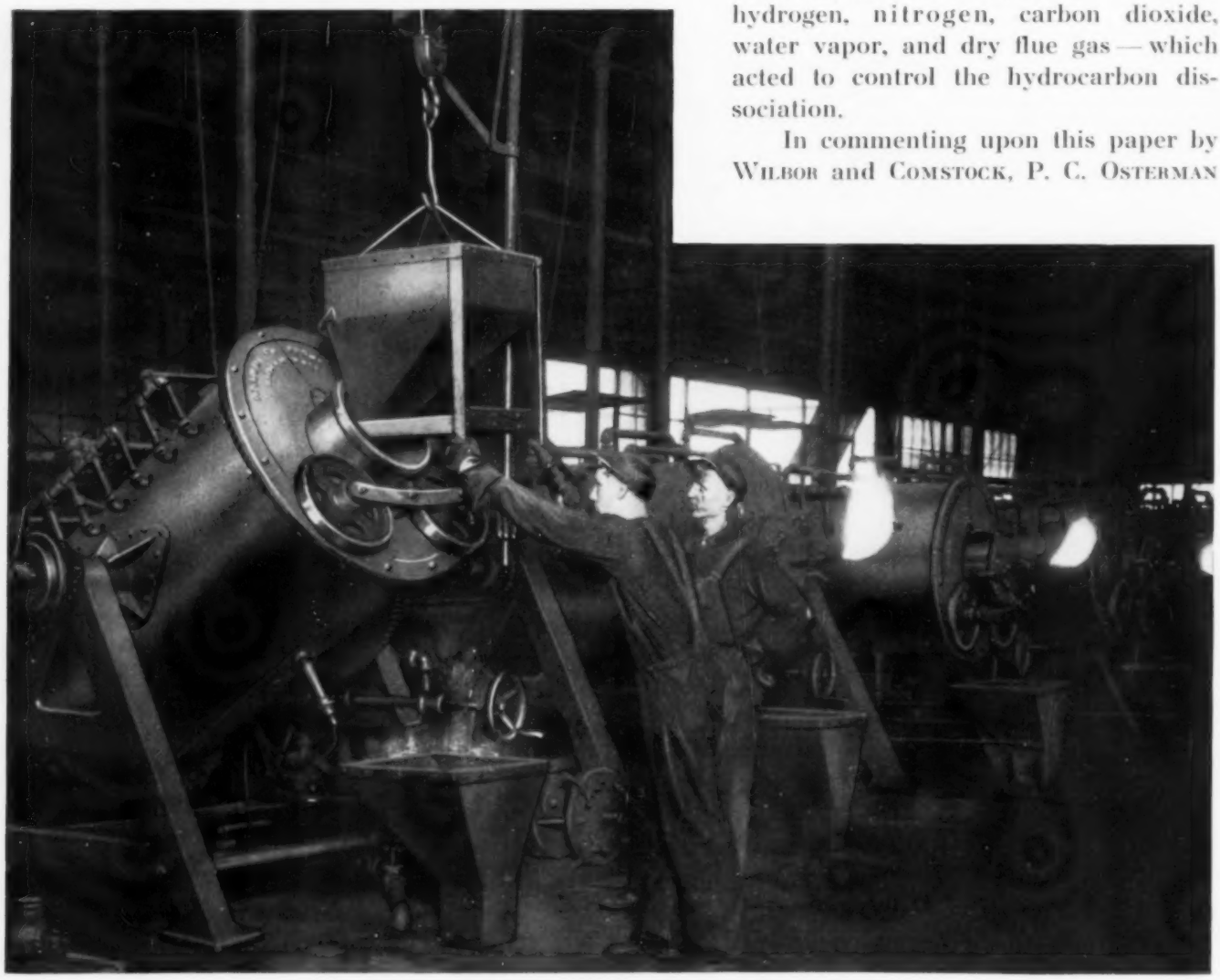
All of these installations were of the rotary type shown on the next page. However, it might be well to mention that experimental work was conducted initially on the vertical stationary type of furnace (page 263) but was temporarily discontinued due to difficulties with heavy soot deposit. In the rotary, this objectional deposit was continually broken off

the surfaces of the work by the tumbling action.

In 1913 continuous gas carburizing was effected in the rotary furnace through the use of a spiral ribbed retort which automatically moved the work from the feed to the discharge end of the furnace.

The next phase of increased commercial activity on a large scale came between the years 1916 and 1920 through the growth of the automotive industry and general business improvement. Installations at this time were mainly confined to the rotary type of furnace. Later on, about 1924, a few vertical stationary furnaces were installed, but this type did not become popular until 1927 to 1929 when heavier parts came to be carburized in quantity. The continuous gas carburizer, using a horizontal tunnel-shaped heating and carburizing zone, through which the work is pushed, is the product of the last decade and awaited the arrival of convenient and cheap gaseous media, a development that will now be summarized.

Charging One of a Battery of Gas Carburizers, Batch Type. Furnaces in background are in operation; through-put of carburizing gas is burning at exhaust pipes extending from the furnace head. Courtesy American Gas Furnace Co.



Gaseous Media

In a paper read before the ⊜ in 1930 (then the American Society for Steel Treating) O. J. Wilbor and J. A. Comstock pointed out that *any* hydrocarbon gas, regardless of its available carbon content, could be used efficiently as a carburizing medium by an intermittent surge method. Essentially this consisted of a turbulent gas flow at high speed, followed by quiescence for some time. This was particularly applicable to hydrocarbons of high carbon concentration, which under the ordinary method of carburizing would break down and form prohibitive soot deposits. In addition, considerable evidence was presented relative to the means of arriving at a predetermined carbon concentration by using city gas with other gases — such as hydrogen, nitrogen, carbon dioxide, water vapor, and dry flue gas — which acted to control the hydrocarbon dissociation.

In commenting upon this paper by Wilbor and Comstock, P. C. Osterman

ndicated that tests had already been conducted n a rotary furnace using undiluted propane gas as the carburizing agent [as early as 1925, to the EDITOR's personal knowledge]. In view of the heavy and undesirable soot formation in the retort various means were employed to dilute the propane with such agents as steam, charcoal producer gas, nitrogen, and air. It was found that a propane-air mixture yielded results as good as, or better than, other mixtures and had the advantage of being easily and economically obtained. Carbon content was controlled by varying the ratio of air to propane and feeding the mixture continuously to the retort. Further control of carbon concentration at the surface, when using undiluted natural gas, was suggested by allowing a period for diffusion, at the end of the carburizing cycle, wherein no gas was added to the retort.

In 1931, before the American Institute of Mining and Metallurgical Engineers, R. J. COWAN described successful carburizing experiments with natural gas, propane, butane, and acetylene in conjunction with flue gas. These tests ultimately led to the use of continuous gas carburizing on a commercial basis. He indicated the desirability of using carbon dioxide in the form of flue gas as a means of obtaining a proper mixture of carburizing gases, this being a feature of his process wherein the carbon dioxide reacts with carbon deposited on the parts to form carbon monoxide, which in turn promotes carburization. Three distinct zones were recognized to exist in the muffle of the furnace. Near the feed end of the furnace the work became coated with a deposit of free carbon due to partial dissociation of the hydrocarbon gas. In the second zone active carburization took place while in the third zone this effect was slowed down and time allowed for diffusion to occur, thereby permitting a gradual carbon gradation from case to core.

So much for the development of fundamentals, furnaces and gases.

In present-day carburizing practice the furnace types may be classified as batch or continuous. The former may have a horizontal rotating retort (gas or electrically heated) and this design is suitable for parts which are not injured by tumbling — rather they are benefited by this action which continuously removes soot from the parts, carburizes more uniformly and produces cleaner surfaces. Or the retort may be vertical and stationary, gas or electrically heated, with or without mechanical agitation of the gas; it uniformly carburizes by regulating the gas mixtures and flow. This type is also built for operation with certain liquid hydrocarbons as the source of carburizing medium; see the drawing on page 264. The vertical batch type furnace is particularly adaptable to parts too large and heavy for rotary furnaces.

The pioneering furnace builder in this field furnishes equipment designed for heating the retort with gas. The first engraving (page 262) shows rotary gas carburizers of this type, one being charged with parts. After removing the head from the retort, the parts are loaded and the head replaced. Following this, the carburizing gas is permitted to flow for a very short time to flush air out, and then turned off while the charge is brought up to heat. When the charge is at the desired temperature, the carburizing gas is turned on and permitted to flow for the balance of the cycle (if the practice being followed so dictates). In order to produce a more uniform temperature of the charge it is well to tilt the furnace upward and downward at definite intervals. To discharge, the gas is shut off, the

Unloading a Charge of Large Gears From Pit Type Gas Carburizer at the Massey-Harris Co., Manufacturers of Farm Equipment, Racine, Wis. Operator stands near heat interchanger

head removed, the furnace tilted forward and slow rotation of the retort will clear it quickly. Usually a quench tank is placed in a pit immediately in front of the furnace, and the hot metal parts transferred by a short chute. The present writer's firm operates a battery of 13 furnaces of this sort, some gas fired and some electrically heated, each one placed in a cubical box-like shell of efficient insulation. Carburizing gas is a mixture of one part propane and two parts air.

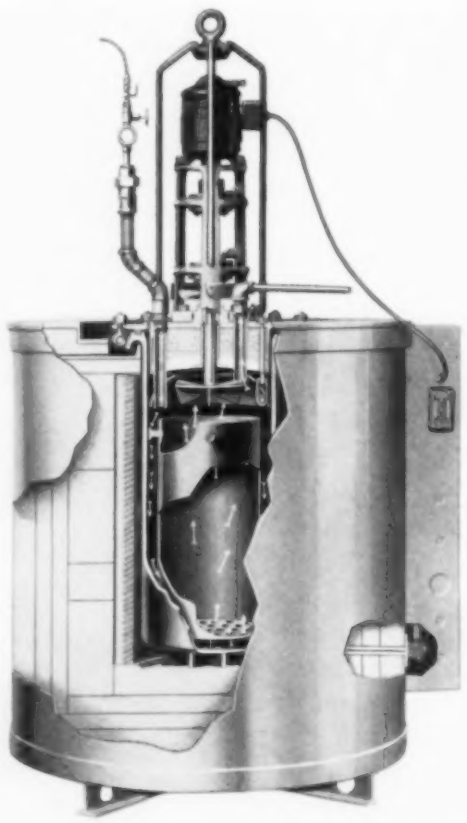
The same gas mixture is used in the vertical stationary retort below the floor of the second view (page 263). To avoid soot deposit the gas is passed through conditioning towers before use. This type of furnace has been improved over early units by lengthening the retort, thus increasing the capacity and distributing the heat more uniformly.

Another company has developed a pit type carburizing furnace with a fan for circulating the gases and with radiant tube heating elements. The fan gives a better gas distribution and excellent uniformity of heating; radiant tube heating elements eliminate the necessity for a retort.

One important factor to consider is gas flow through the muffle or through any sort of furnace. Stratification or stagnation of the gases will cause some part of the load to carburize lighter than in another region.

The same company offers a stationary batch furnace with a horizontal muffle, including a gas generator and control panel. This particular unit offers economy where the amount of carburizing is relatively small. Operation, as described by E. F. Davis in his paper in the ASM Carburizing Symposium (1937), starts with charging the tray and work into the muffle and closing the door. The air which entered during loading may be displaced by gas made by partly burning city gas with air in the proportion of three air to one gas. The purging continues for about 1½ hr. as the work is coming up to heat. When the temperature has reached about 1550° F. straight natural gas or its equivalent is supplied at the rate of about 50 cu.ft. per hr. Next, the carburizing period is started, during which natural gas diluted with partly burned gas is supplied until completion of the cycle. The parts are then withdrawn and quenched (or slowly cooled, depending on circumstances).

One particular type of electrically heated carburizing unit, introduced about 1930, is designed to operate as a stationary batch furnace with forced circulation of the atmosphere. No extensive equipment for preparation of the carburizing gas is needed as it generally utilizes a hydrocarbon liquid, metered and dropped or pumped through an opening in the cover, either onto a hot target or — as shown on this page — between basket and retort which causes the oil to "crack" partially and form the carburizing medium without the presence of diluting or oxidizing agents. As the carburizing gas is formed in the furnace, it is circulated through the work by a large fan. This forced circulation continues during the entire carburizing cycle, insuring uniform distribution of temperature and gas to all surfaces of the load; spent gases are ignited at the outlet in the lid. Forced circulation uniformly carburizes small parts loaded at random and in intimate contact. Diffusion of carbon in the case may be accomplished by cutting off the supply and holding the charge at heat for a time.



Phantom Drawing of a Modern Carburizer, Vertical Type, Electrically Heated. A retort separates work basket and resistors, and the carburizing medium, introduced through cover, is violently circulated through the work by a fan at top. Courtesy Hevi Duty Electric Co.

The second main subdivision in a classification of furnaces contains those for continuous operation on a flow of material. Aside from the rotary muffle type mentioned at the

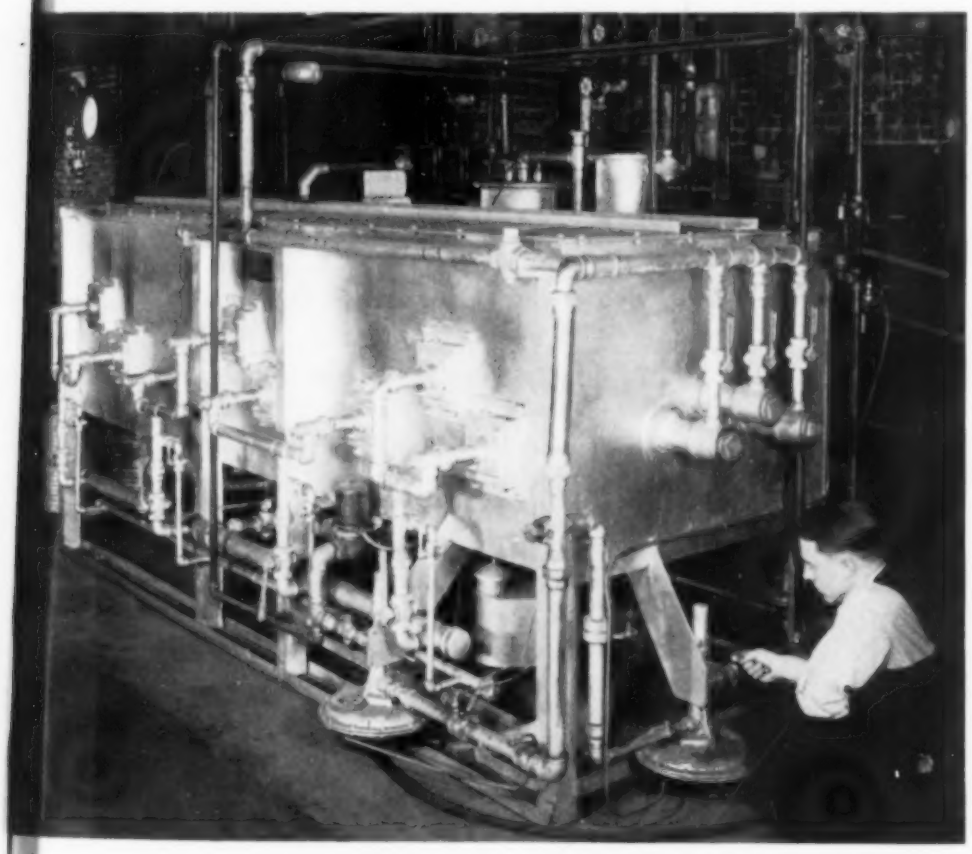
outset they are generally of the pusher tray type. Parts are carried on fixtures or trays built for automatic quenching, for hand quenching, or for slow cooling in a cooling zone built onto the discharge end of the carburizing zone.

An early furnace of this sort has been described in considerable detail in METAL PROGRESS by R. J. COWAN (February 1932 and October 1933). Essentially it is a long, low, refractory-lined steel shell containing an alloy muffle, over and under fired. Carburizing gas is introduced at several points along the top of the muffle, the amount being adjusted to produce the desired results. At both ends of the furnace, large, air-operated valves or doors effectively seal the muffle. Extensions of the muffle beyond these valves form two external chambers closed at their outer ends by manually operated doors. The chamber at the charging end is used as a purging chamber or gas lock in which all oxygen is expelled by means of flue gas or heating gas. The corresponding chamber at the discharge end, sometimes called a holding chamber, is used to bring the work to any desired temperature prior to quenching and to provide a short diffusion period.

L. D. GABLE and E. S. ROWLAND have indicated in their paper in the 1937 ASM Carburizing Symposium that carbon gradation and maximum carbon concentration can be controlled by proper dilution of the rich hydrocarbon gas with a prepared base gas. When using diluted natural gas, one of Surface Combustion's "DX units" may be employed to prepare burned gas of constant composition from natural gas. In this unit, practically perfect combustion of the air and natural gas occurs and a flue gas of almost any desired composition can be produced. Its activity is regulated by the ratio of volume of natural gas to volume of diluent gas. This base gas performs another very important function through proper distribution of the rich hydrocarbon gas throughout the partially spent gases in the furnace.

When using propane or butane as the carburizing medium in the continuous method, practically all commercial installations utilize some means of dilution. The engraving on this page shows an improved unit designed to provide cracked gas for mixing purposes. In it, the hydrocarbon gas is diluted with air in the proportions of one part natural gas propane to, say, seven parts air, or one part natural gas butane to ten parts air, and run through tubes externally heated higher than carburizing temperature in order to crack the hydrocarbons so no tar or soot will form later on the work. This gas is cooled by a water spray in a closed tower and then dried in another tower by calcium chloride. Finally, the gas is passed through a tower packed with excelsior and led to the furnace where it is mixed with natural gas propane or butane at the inlets.

A recently developed gas generating unit producing a charcoal gas comprises a series of tubes filled with charcoal which are heated externally while dry air in regulated amounts is passed through. This gives a gas that is about one part CO to two parts N_2, with a little CO_2.



Modern Gas Preparation Unit (Surface Combustion) Where Mixtures of Liquid Hydrocarbons and Air Are Heated and Combined When Passing Through Hot Tubes at a Temperature Higher Than They Will Subsequently Experience in Use. Subsequent treatment may then remove detrimental compounds — principally water vapor

Where natural gas is available it is used for gas carburizing because of its relative purity, and for its high content of the rather sluggish reacting methane which makes the gas easy to control. When it cannot be obtained the choice lies between propane or butane and city gas. With few exceptions, the former have been selected. The main objection to manufactured gas is a low and variable hydrocarbon content; on the other hand, propane and butane form condensable liquids during the slow heating in that part of the furnace where the work is coming to temperature. These deposits on the work

"NiCarb" Furnace at Hyatt Plant, Puttin ings Light Case on Roller Bearing Cages — Stamp ooo

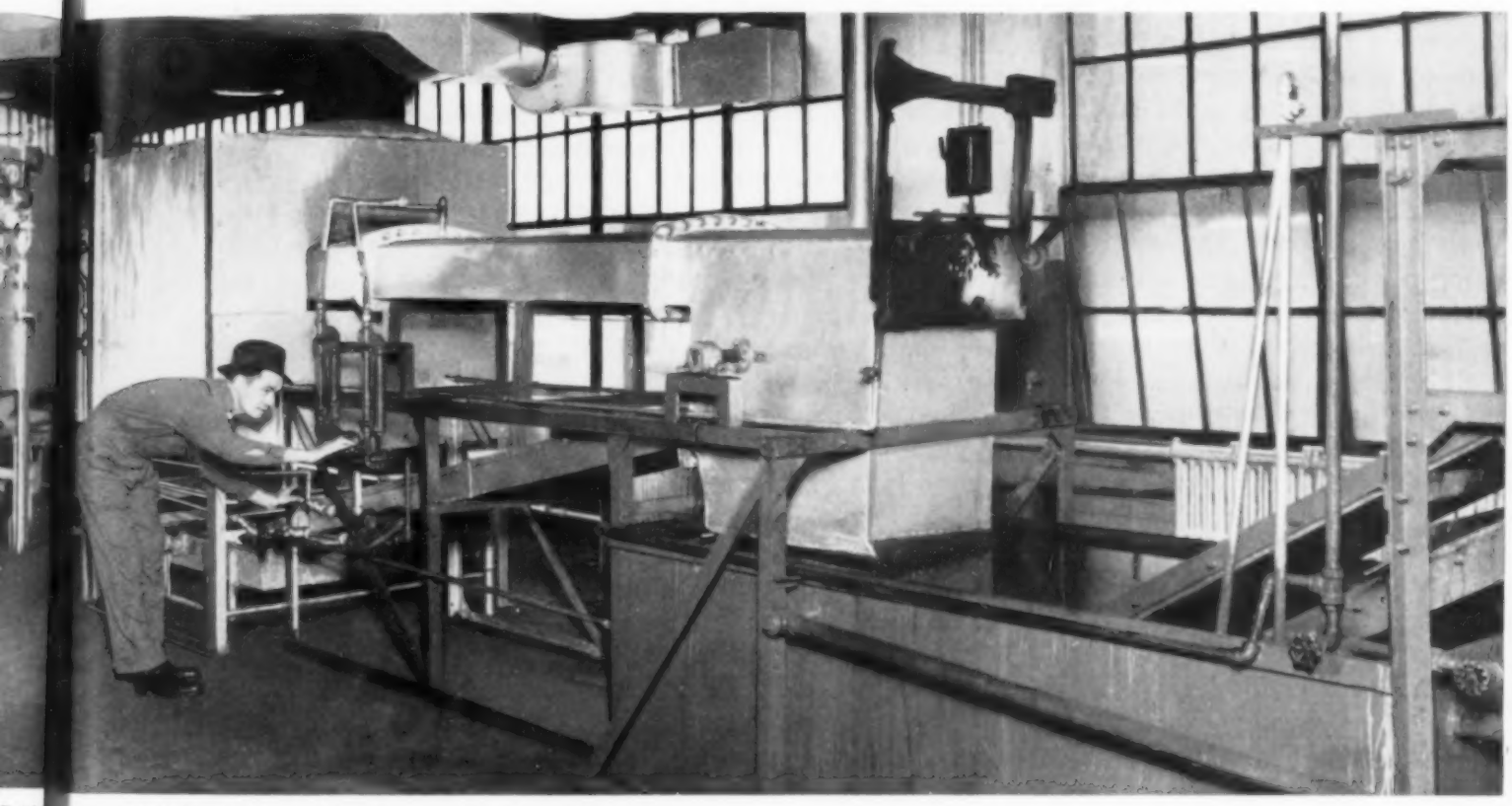
are carried into the high temperature carburizing zone where they form hard carbon or coke upon the surface to be carburized, thereby interfering with uniform penetration. This condition is aggravated when using refinery propane or butane which respectively contain liberal percentages of propylene or butylene, resulting in spotty carburization regardless of whether used pure or diluted. Gases free from these unsaturated hydrocarbons are preferable. Two ways will overcome these difficulties. One is by dilution with a carburizing gas high in hydrogen and the other is by introducing most of this gas into the high temperature zone of the muffle. The high hydrogen diluent lowers the tendency toward tar formation; similar benefits are derived through a rapid thermal breakdown.

Some of the most recent furnaces use radiant tubes (metal combustion chambers) for heating instead of long muffles externally fired. One such for carburizing auto transmission parts was described by WILBUR E. SANDERS, J. L. COYLE and W. A. DARRAH in METAL PROGRESS for December 1938.

An entirely different method is featured in equipment described last winter by J. A. Dow of Holcroft and Co. before the Peoria Chapter, mentioned briefly in "Critical Points" in the May METAL PROGRESS, and shown in the drawing at the end of this article. It utilizes the spent carburizing gases from the muffle to provide the necessary diluent for the incoming rich hydrocarbon gas through the principle of recirculation. It is said to eliminate carbon dioxide and water vapor which are particularly offensive oxidizers and decarburizers. In this respect it differs widely from the other continuous methods where a base gas is prepared externally and never scrubbed free of CO_2 nor dried carefully prior to its single passage through the muffle. Recirculation of either natural gas, or a mixture of manufactured gas and propane, is simple and does not require a gas generator.

The practical absence of decarburizing agents makes it easy to regulate the activity at various points in the carburizing zone, thus producing the type of case desired. Without the necessity of forced circulation through a load of work, uniformity of case with cleanliness of surface is obtained and materials may be stacked more densely. Since recirculation does not dilute the hydrocarbon gas with nitrogen, it yields the highest methane percentages in the muffle gas obtainable with the given gas supply. As a result, carburizing is accomplished with exceptional freedom from soot. The sectional view of this furnace shown on page 268 is of a furnace using radiant tubes above and below the work. The recirculation system is shown; it includes control valves and measuring orifices for the recirculated and hydrocarbon gas. The furnace is equipped with a "Thermeter" to give a continuous record of the thermal value of the gas drawn from the furnace; this in turn is a measure of the methane content. The hydrocarbon gas addition is regulated to maintain a constant B.t.u. reading.

Furnaces so far described are primarily adapted for medium and deep cases. The "NiCarb" process is a distinct method of obtaining light cases. Such a unit is shown in the engravings on pages 266 and 267. Through the use of a carburizing gas atmosphere, as for instance natural gas propane, mixed with about ten parts ammonia, it is possible to produce case depths of at least 0.015 in. on an S.A.E. 1010 steel, similar in character to a cyanided case, file hard, without quenching and with minimum distortion. The discharge end of the furnace has a cooling section and gas seal to prevent infiltration of air. This process is offered by several furnace manufacturers for casehardening low and high carbon steels with and without quenching. Depths of case generally up to about 0.015 in. are obtained; however, it is possible to get depths of $\frac{1}{32}$ in. or more.



Putting ... ings of 1010 Steel. Discharge is through a Stamp... cooling prolong, watersealed by quenching tank

Conclusion

Analyzing over-all operating conditions, the gas method is cleaner, promotes better working conditions, requires less floor space and may be conveniently located in the production line.

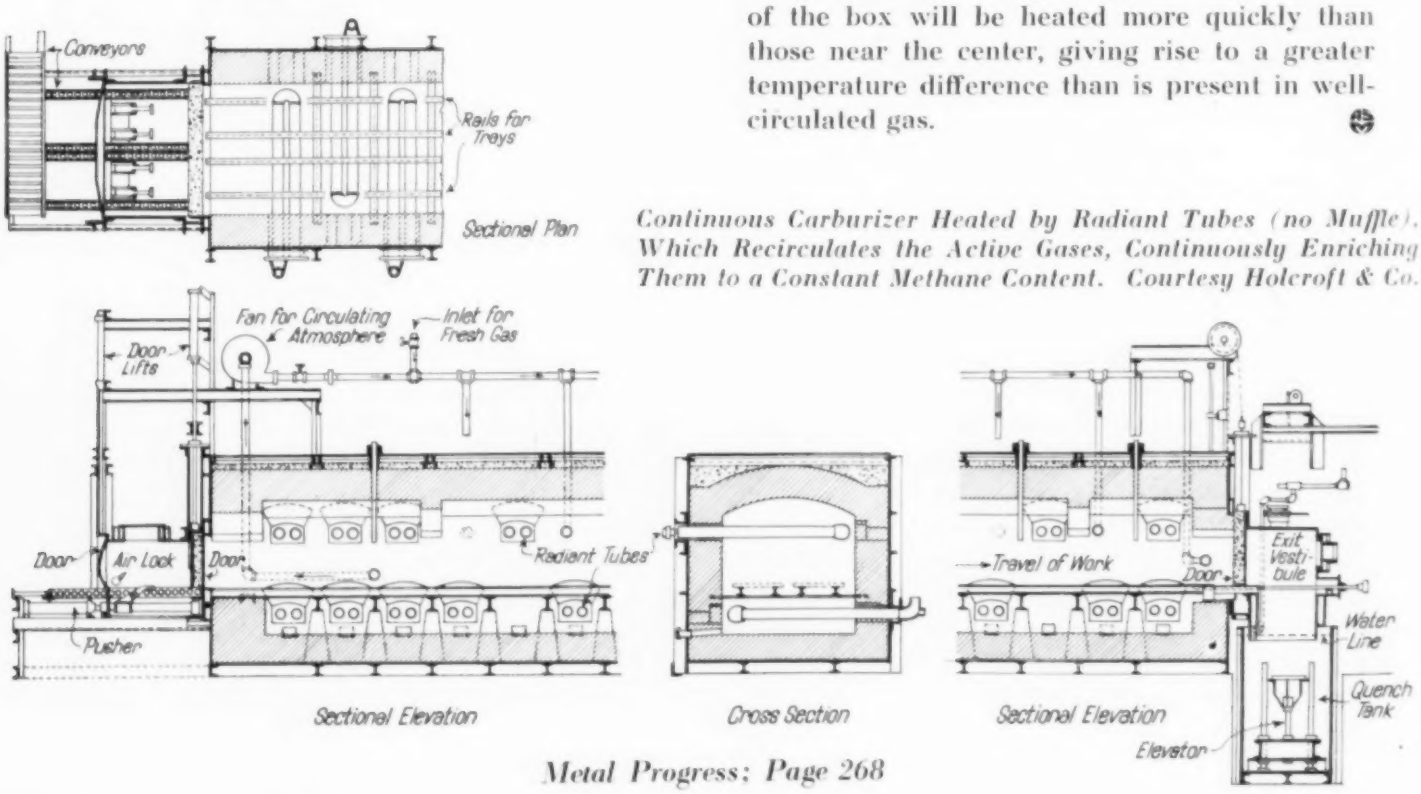
From the standpoint of relative cost of investment the original expense of a gas carburizing unit may be higher than a unit designed to use solid compound. Probably it is advantageous to use this method where the produc-

tion demands are sufficiently large to justify the investment. Compound might be advantageously used where the production is not large.

Time for the complete operation can be saved when using gas by virtue of rapid heating of the parts as they enter the furnace in baskets or trays which are designed to permit the full effect of direct radiant heating from the retort. Consequently, the work reaches carburizing temperature quicker than when buried in compound wherein the containers and the compound both insulate the work from rapid heating. However, the rate of carbon penetration is about the same in the two methods, gas and compound, once the carburizing temperature is reached. Further reduction in over-all time is realized by faster and easier loading and unloading. When gas carburizing, work is loaded into open baskets, relatively light in weight, and charged directly into the furnace; compounds require a closed container and very much slower rate of packing. Finally, if the work is to be quenched direct from carburizing heat, many disadvantages normally encountered with hot compound are avoided.

From the standpoint of quality of product it is often desirable to control the carbon concentration in the carburized case. To accomplish this with compound it is necessary to utilize various types of carburizer, which in itself usually adds materially to costs. For instance, it may be desirable to use boneblack to obtain a carbon concentration near eutectoid composition. This material has a high density and is a very poor heat conductor. On the other hand, a richer carbon concentration may be had by using a charcoal-coke base compound which, at the same time, permits more rapid heating than boneblack. Turning to gas carburizing, we find the same control of carbon may be had in several ways, such as varying the type of gases, mixture, rate of flow, distribution and diffusion. It is apparent that these methods are easier, more flexible and within economic limits. Further improvement in quality is realized with gas carburizing on occasions where it is desirable to produce a very deep case. The extended length of time at heat would eventually exhaust a compound of further carburizing action, in which case it would be necessary to replace with new material and recarburize. In the gas method, a constant supply of fresh carburizing medium is always available so that carbon penetration will continue to any desired depth.

On the other hand it might be stated in connection with temperature uniformity of the parts being processed that in gas carburizing any sudden or drastic change in heating is quickly followed by a corresponding temperature change in the work. This particular sensitivity is not so pronounced when carburizing in compound since the hot carburizer resists temperature changes due to its poor heat conductivity. However, assuming a constant heating effect in the muffle it is apparent that in compound carburizing the parts near the sides of the box will be heated more quickly than those near the center, giving rise to a greater temperature difference than is present in well-circulated gas.



Continuous Carburizer Heated by Radiant Tubes (no Muffle), Which Recirculates the Active Gases, Continuously Enriching Them to a Constant Methane Content. Courtesy Holcroft & Co.

Critical Points

By The Editor

THINKING sadly that a macabre answer has probably been found for our ten-year question "Where are we to find a new industry to absorb our surplus labor and capital?" The new industry is to be the munitions industry, or rather the defense industry, since production of munitions and our new army, navy and air forces will absorb many millions of men. Oh, to be a prophet, to know what effect such an enormous non-profit-making industry will have on our economy. All expense, no income, only insurance! But if Uncle Sam is going to build up the biggest defense industry in the world, it should be run like our other successful industries. It is all right to produce what ships, guns, tanks, aircraft we know how to produce, and to get going quickly. But it is also imperative to start working on improvements, to start thinking about the ships, guns, tanks and aircraft we should be making in 1950. No Model T's for us! Of course the Navy, having always been on a war footing, is better off than the other services, and has three experimental stations; the Army Aircraft has done much good work at the fields at Dayton and Hampton, and has three laboratories a-building under the direction of the National Advisory Committee for Aeronautics; and the Army Ordnance does some research in its arsenals, notably at Watertown. But a multi-billion dollar industry needs an honest-to-God central research department, in charge of a coordinator who knows how to get the answers. Else how is our defense industry to meet competition of the sort that totalitarian militarism turns loose?

Organize munitions research

TO the bustling plant of Doehler Die Casting Co. at Toledo, and pondered that an idea about how to make accurate castings could grow so large in 35 years. J. C. (Joe) Fox, chief metallurgist, told me that lack of a steel with which to make durable dies is still the bottleneck as far as brass casting is concerned. The brasses themselves are now capable of 110,000 psi. in tension with 5% elongation; such a one is a somewhat complex alloy containing 10% zinc and 1% each of silicon, manganese and aluminum. (By the way, electrolytic manganese, when substituted for the best furnace-made metal, eliminates undesirable iron and carbon contamination in this casting, and the melt remains constant in composition much longer — obviously essential in a process that works from a lake of metal.) But even the best die steels are covered with alligator cracks in fairly short runs on brass. Fox has tried every toolsteel and many special analyses in the moderate and the high alloy classifications, and is willing and anxious to try anything that anyone would suggest and that is procurable in a 1-in. cube. For testing such steels he makes it into a die for a small square plate and inserts it into one section of a multiple die in production. One side of the test die is the material under test, the other side for reference is the die steel now used. Most metals check in less than a day's running. Best so far

Wanted: a die steel for brass casting

discovered, and the one currently in use by Doehler, is the hot work die steel containing about 10% tungsten and 3% chromium. Success requires great strength (resistance to wear or alloy wash) when nearly as hot as liquid brass. Possibly also a minor porosity is desirable, so that the repeatedly expanding metal will have somewhere to go.

Metallurgy in oil field machinery

TALKING with M. T. ARCHER, director of research for National Supply Co., who said that the metallurgical problems in the making of oil well drilling and pumping machinery necessitate the extensive use of alloys and advanced metallurgical technique in their treatment. In fact, this activity consumes more pounds of alloy steel than automobiles do. Surprised to learn that cable drilling (or churn drilling) goes back to prehistoric China; there they drilled for salt brines, and later for natural gas to evaporate it. Modern rotary drilling is an adaptation of the diamond drilling first used in the Mt. Cenis alpine tunnel 80 years ago. Today's equipment for deep drilling, as operated full size at the New York World's Fair, depends on many details, invented and perfected within the last 30 years, requiring the utmost care and good engineering. Approximately 5000 cards are in Chief Metallurgist ROBERT ADAMS' file, each one containing detailed instructions for the heat treatment of a current part of engine, gear, shaft, pump part, or part for drill rigs or draw works. So there *is* considerable metallurgy in National Supply Co.'s products, and that second to none in quality, put there not to reduce weight or cut the cost, but to insure the utmost reliability under severest conditions.

INTERESTED to learn of the transverse tests made on forging billets for "tool joints", those husky threaded connections that join the various parts of the drill stem into a single string. HARRY HEINISCH, assistant metallurgist at the Toledo plant of National Supply Co., said no material anywhere is abused so much as the threads on the "pin" and "box", the male and female part of the conical union. The string must be drawn out frequently to renew the drill bit; on reassembling, the joints between 90-ft. sections of pipe are rapidly "stabbed", and the ton or more weight slams down on the leading edges of the threads. The joint is spun up by a rolling hitch of manila rope about the stem and the winch's nigger-head, and "tonged" tight with approximately 16,000 ft-lb. torque. Yet the threads must not gall, seize, chip or wear unduly; the box must not split due to the wedging force of the conical pin. Fatigue fractures, once frequent at the last engaged pipe thread, are now avoided by stronger metal and better design to relieve stresses. The first alloy steel joints were made in quantity about 20 years ago; now all manufacturers use a medium carbon, alloy steel like S.A.E. 3145, 4145 or 4245. Molybdenum added to 3145 Ni-Cr steel (4245) promotes uniform hardenability and a high level of machinability in quenched and tempered forgings. Inspection by HEINISCH's staff is severe; the forging billets are about 5 in. square, and a cubical sample is sawed from one billet in every ten tons. This is deep-etched and any suspicious area examined microscopically for slag content, comparing it against the General Motors' standards (METAL PROGRESS, October 1939, page 448). A tension test piece is then cut transverse to the rolling direction and normal to any suspicious porosity or woodiness; it is heat treated as the joint will be, and pulled. The transverse ductility figures must be more than 10% elongation and 20% reduction of area. (Minimum longitudinal tensile properties of a completed joint are 135,000 psi. yield, 150,000 ultimate, 18% elongation and 45% reduction of area — but the joints never fail in direct tension.) Manufacturing routine, in a production line, includes forging in a mammoth upsetter, normalizing, all machining except threading, heat treatment, testing both ends for hardness, grinding exterior, cutting threads with cobalt high speed tools, copper plating threads for non-galling, inspecting with several accurate gages. Hardness limits are Brinell 302 to 341; if an

Tool joints must not burst, wear, or "fatigue"

individual joint is sawn lengthwise and the hardness surveyed, it is constant end to end and edge to center within observational error.

TO THE BUSTLING South Side Works of Jones & Laughlin Steel Corp., where D. R. (DAN) LOUGHREY, assistant superintendent of openhearths and bessemers, demonstrated the flame control by electric eye, recently developed to aid the blowers secure uniform metal — a notable advance in a traditional art, and a useful and timely one, what with the urgent demand for tonnage steels and the general improvement in fast machining ones. The electron tube ("eye") is screened by special filters, and is set some 50 ft. away from the vessel in unobstructed view of the flame. Its current is appropriately amplified and operates a recording milli-ammeter in the pulpit. In the course of the blow the recorder pen swings rapidly up to a maximum, where it remains more or less stationary for several minutes, indeed almost to the end of the blow (what with the judicious regulation of the blast to keep the partly blown metal from getting too hot). Suddenly the recorder pen falls as steeply as it rose, with no correspondingly large or sudden change in the color or volume of the flame — at least to this untrained eye. This sudden drop in the amount of radiation is not the important criterion, although it must have some real significance; last percentages of carbon are rapidly approaching zero at the time, and two thirds of the way down there is a slight arrest in the radiation-time curve. LOUGHREY said it sometimes resembled a recalescence. *That* is what the blowers watch for; they turn the converter down and shut off the wind after a few seconds — a measured time depending on the silicon and manganese in the pig iron (that is, the amount of slag in the converter at the end of the blow), and the number of blind tuyeres (that is, the volume of air actually being blown). Any natural antipathy of veteran steelmakers to this robot has vanished as they became convinced that it was accurate more often than their eyes, especially on a blue Monday or in fickle weather. J. H. (JOE) FLAHERTY, metallurgist of the Pittsburgh Works, says that a notable improvement in machinability of bessemer screw stock has come about, through scientific flame control, not so much in an improvement in the machinability of the best heats, as it is in the certain elimination of those below-average heats that really limit the machine tool performances.

Bessemer flame control

LUNCHING with RAY BAYLESS's numerous experts who act as the ⊜ Publication Committee. On one side was B. L. (BEN) MCCARTHY, metallurgist for Wickwire Spencer Steel Co. and this year's Mordica Memorial Lecturer for the Wire Association. He was worried about methods and costs of reproducing micros of wire structure in Kodachrome. On the other was SAM TOUR, vice-president of Lucius Pitkin, Inc. and consultant for C. I. (Certain Curtain Furnace) Hayes. He had done enough work on moly high speed to decide that soft surface is more often due to retained austenite than loss of carbon or molybdenum. Extra carbon and retained austenite have also been found by others on the standard 18-4-1 high speed steel after quenching. Such surface austenite on 18-4-1 has been transformed into martensite, with increase in hardness, by leaving on a block of dry ice over night, or by a double tempering at 1050° F. TOUR finds that the soft surface austenite on hardened molybdenum high speed is often so stable as to resist both these treatments. He had hoped to be able to identify and distinguish between soft skins due to decarburization and these soft austenite skins due to carburization by the "Magne-Gage" so useful in determining the thickness of nickel coatings on steel, but variations in amount and distribution of nonmagnetic gamma iron and magnetic alpha iron (austenite and martensite respectively) in the body of the quenched steel throw the readings out of line.

Soft skin is retained austenite

Burnie Lee Benbow

Progressive Executive
in Metallurgical
Industry

"TO BURNIE LEE BENBOW, who typifies the progressive executive, this book is dedicated." So concludes the paragraph of dedication in JEFFRIES and ARCHER's "The Science of Metals" which since its publication in 1924 has come to be recognized as an outstanding treatise in the field of physical metallurgy.

BURNIE LEE BENBOW, known to his many friends as "BENNIE", is indeed an individualist who occupies a unique position in the industrial world as manager of the Cleveland Wire Works, Incandescent Lamp Department of the General Electric Co. The present modern plant of the Wire Works, located near Cleveland in Euclid, Ohio, was built around BENNIE's plans and embodies many of his progressive ideas.

Surrounded in his office by an extensive library and convenient blackboards, he resembles more a college professor than an industrial executive — until he goes into action. In this office many a "30-min. conference" has developed into a symposium, lasting far into the night, an occurrence which is familiar to all of BENNIE's staff and to many of the casual visitors who continually drop in to talk over a wide variety of engineering problems.

In 1908, after completing his training in electrical engineering at Purdue, the young graduate came to the National Lamp Works, then located in down-town Cleveland, in the industrial district bordering the Pennsylvania railroad. At about this time, the process for drawing tungsten filament wire was passing from the laboratory to the commercial stage. One of the problems on which the young engineer labored was that of making this process commercially workable. His achievements may have been partly due to his habit of living on the job, day and night. In this practice he still persists when the occasion demands.

Some years later, in 1914, after serious and continued difficulties had been encountered in working the tungsten metal, Mr. BENBOW, then manager of the Cleveland Wire Works Division, sought the aid of ZAY JEFFRIES who was at that time teaching in the department of metallurgy at Case School of Applied Science. The success which followed the introduction of metallographic methods and the analysis of the problem from the standpoint of physical metallurgy appears to have awakened in the manager an enthusiastic and lasting interest in the advanced physical sciences.

Shortly after the War, he sponsored the construction of one of the earliest installations for the study of metals by X-ray diffraction. This work was done under the immediate supervision of EDGAR C. BAIN and the application of the method and interpretation of the resulting data were keenly followed by the sympathetic manager.

To design, construct and operate a commercial plant for the recovery of argon and other rare gases from the atmosphere was his next successful endeavor. Finally, in order to determine and control the purity of the gaseous and metallic products of the Wire Works, he furthered the design and construction of a grating spectrometer which is unsurpassed in resolving power by any similar industrial installation. This apparatus embodies his conviction that precision instruments should be built on the rugged lines of a production machine rather than as a piece of laboratory equipment.

The foregoing examples represent some of the high lights of a unique industrial career. BURNIE BENBOW has always maintained as a goal, improved quality with corresponding economic savings attained by methods of scientific analysis.

A well rounded selection of stories and personal anecdotes related in a highly animated and vigorous style serves to temper the rigor of BENNIE's technical conversation. He is ever ready to help the fellow who is making an effort, and has made it possible for many a young man to complete his education or to gain a foot-hold in the engineering profession. Throughout the plant his employees regard him with confidence, affection and esteem.

Spot Welding of Aluminum for Aircraft

By L. P. Wood

Abstract of "Welding in the Aircraft Industry",
The Welding Journal, *July 1940, page 476*

IT IS APPARENT to even a casual observer that a real bottleneck in the production of medium to large aircraft exists in the necessity of driving a staggering number of small rivets in all joints in the aluminum frame and covering. Spot welding is an attractive alternative. Difficulties in welding the strong aluminum and alclad alloys have been surmounted and a considerable amount of such work has accordingly been done by aircraft builders on non-structural assemblies. Costs are naturally lower, reliably estimated to be between 0.25 and 0.30¢. This compares with the cost of driving the average rivet which various manufacturers estimate between 1.5 and 3.5¢.

As experience accumulated, both in the shop operations and in the service of the spot welded parts, their use gradually spread to semi-structural and then to structural assemblies. There have been very few unfavorable reports, and spot welding has now ceased to be a novelty in aircraft factories and is a standard production tool. However, the use of spot welding on structural parts has only begun to get a foothold, even though it is known that it is almost universally used in Europe. Foreign engineers who are in a position to know say that military aircraft now in action in Europe have tens of thousands of spot welds, many in vitally stressed parts.

The first spot welding machines used by the American aircraft industry were no different from those used in other industries on other metals, and this situation has changed little in the past ten years, except that the machines are now somewhat more refined and more carefully controlled. Foreign manufacturers attacked the problem from a different angle and devoted special study to new types of welding machines. The most successful of such machines is that manufactured by MARIO SCIAKY, a French engineer. His machines are now made in Chicago by an American branch of the French-English Sciaky Co. of Paris, and most American aircraft companies making all-metal planes have installed one or more of them.

Aluminum, on exposure to air, rapidly acquires a thin, transparent film of oxide that is an electrical insulator. For uniform spot welding, therefore, this film must be removed or effectively broken through. Practically all aircraft makers clean the surfaces shortly before welding. One chemical method is to make a heavy, gelatin-like solution containing hydrofluoric acid and a wetting agent, brush this along the seams to be welded, allow to stand a few minutes and wash thoroughly. This leaves an etched surface which is chemically clean. Another method is to dip the the whole part to be welded in an etching solution, such as hot sodium hydroxide or a similar material which will attack aluminum alloys.

Surfaces are also cleaned by rubbing with emery cloth and steel wool. However, the most widely used method is to use power-driven wire brushes. Aluminum alloys with an outer coating of soft pure aluminum (alclad) must be cleaned with brushes having fine stainless steel bristles so that this thin coating will not be removed. Other aluminum alloys and magnesium alloys are cleaned with ordinary crimped steel brushes.

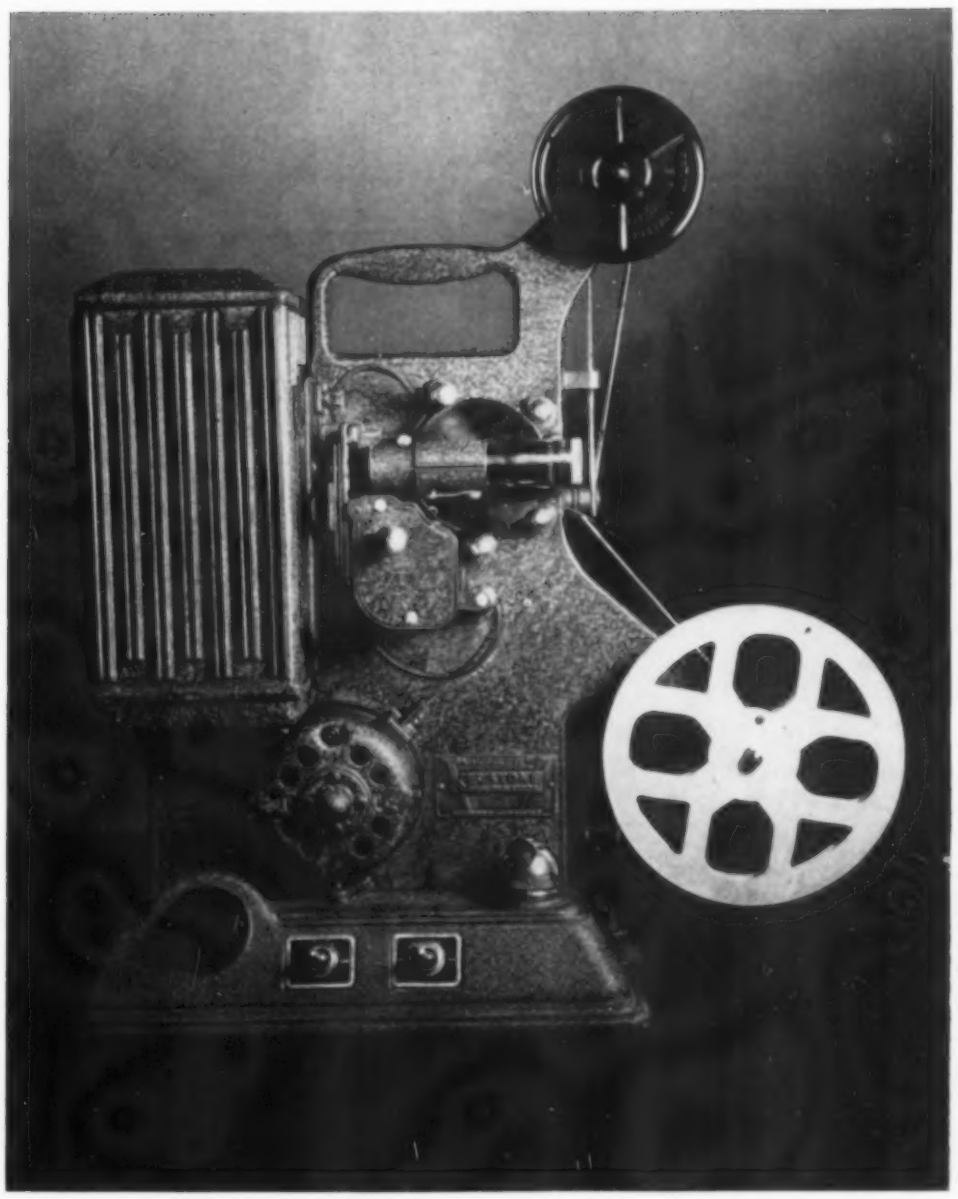
Another important problem to be overcome is related to the low electrical resistance of the aluminum alloys. Alternating currents ranging from 15,000 to 35,000 amperes (direct currents even larger) are necessary to handle the range of alloys and gages used in a fuselage. Accurate and controlled timing is necessary for speed and uniformity (and perhaps also for soundness and strength of the weld).

Since the pressure between the electrodes controls the contact resistance, it should be accurately controlled. Aluminum and magnesium are quite plastic and extra pressure will make undesirable depressions in the surface and cause more rapid deterioration of the electrode tips, which foul and pit all too rapidly even under the best of conditions.

The Sciaky machine embodies two new principles. One is a new use of direct current for resistance welding. The other is the variable pressure cycle. The electrical end of the machine draws power from the regular 3-phase shop circuit converting it into uni-directional impulses in a common mercury vapor arc rectifier. These impulses are led through the primary winding of a "choke" transformer and quickly build up in its core a store of electromagnetic energy. When this store reaches a proper amount, this primary circuit is opened automatically by a "maximum current relay" and the induced flux in the transformer core drops off rapidly and sets up a transient direct current of high amperage *(Continued on page 334)*

Die Casting

The Manufacture of a Projector Frame



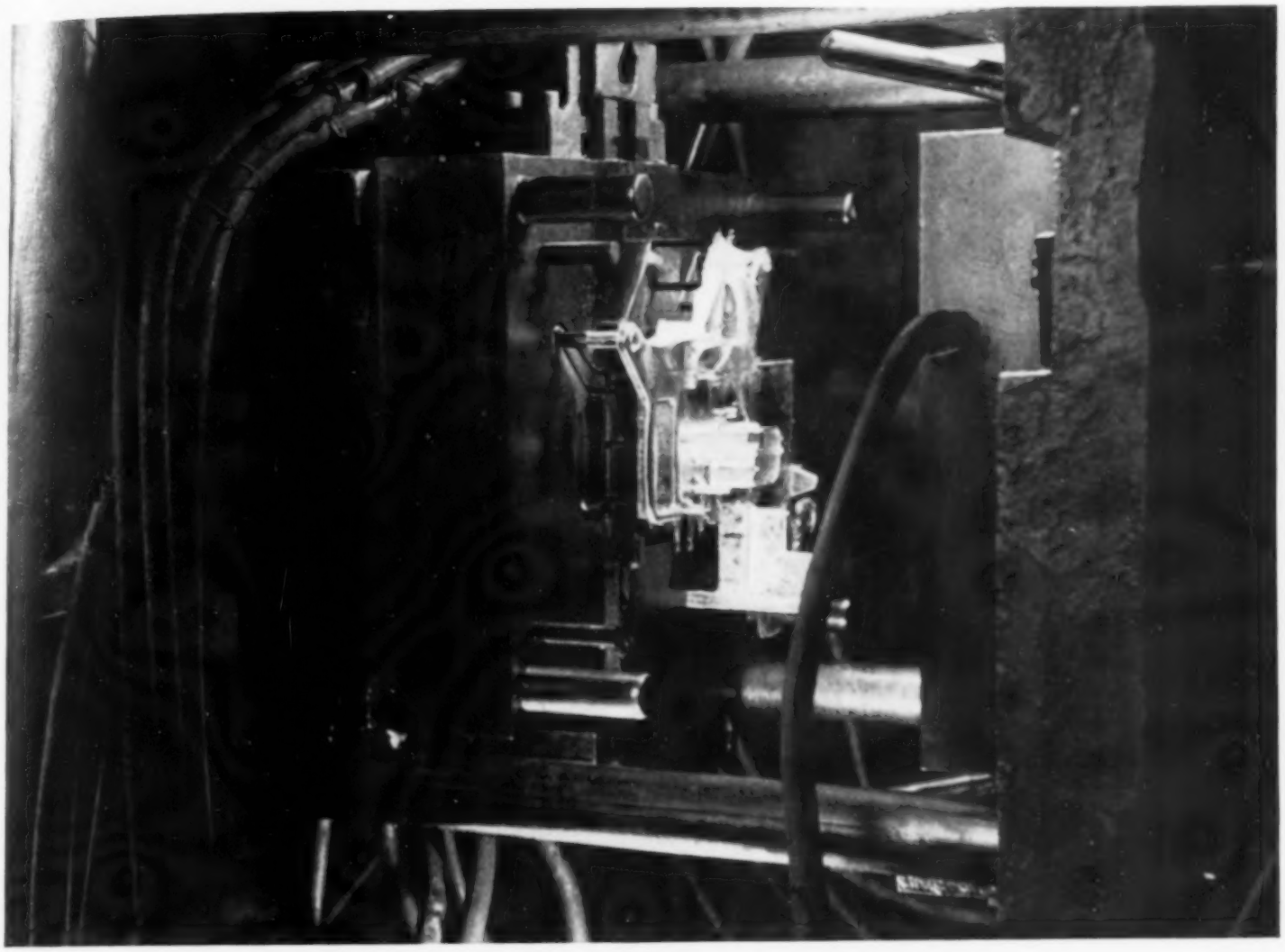
Photographed by
Van Fisher
at
Doehler Die Casting Co.
Pottstown, Pa.

MORE die castings are made of zinc than any other metal. But ordinary zinc will not do; castings having traces of tin, lead or cadmium swell and warp in humid weather, so their wide use awaited "four nines" metal—that is, zinc 99.99% pure. Such metal strengthened by 4% aluminum, and physicked with 0.04% magnesium, is easy to cast into intricate shapes and amply good for innumerable machine parts, grilles and decorative trim.

About 2½ tons of zinc slabs are melted in a large cast iron pot, set in a round brick furnace. Gas flames swirl around inside the setting, and discharge through curved flues to play over the top surface and prevent a chilled crust. (An ample hood has been removed to aid the photographer.) The proper amounts of aluminum and magnesium shot are stirred in by motor driven paddles, and the circulating bath given considerable superheat (actually to about 850° F.) to insure adequate and uniform solution. Oxide dross is skimmed and the alloy is then ready to be pumped out into a sump truck or a ladle for transfer to the die casting machines.

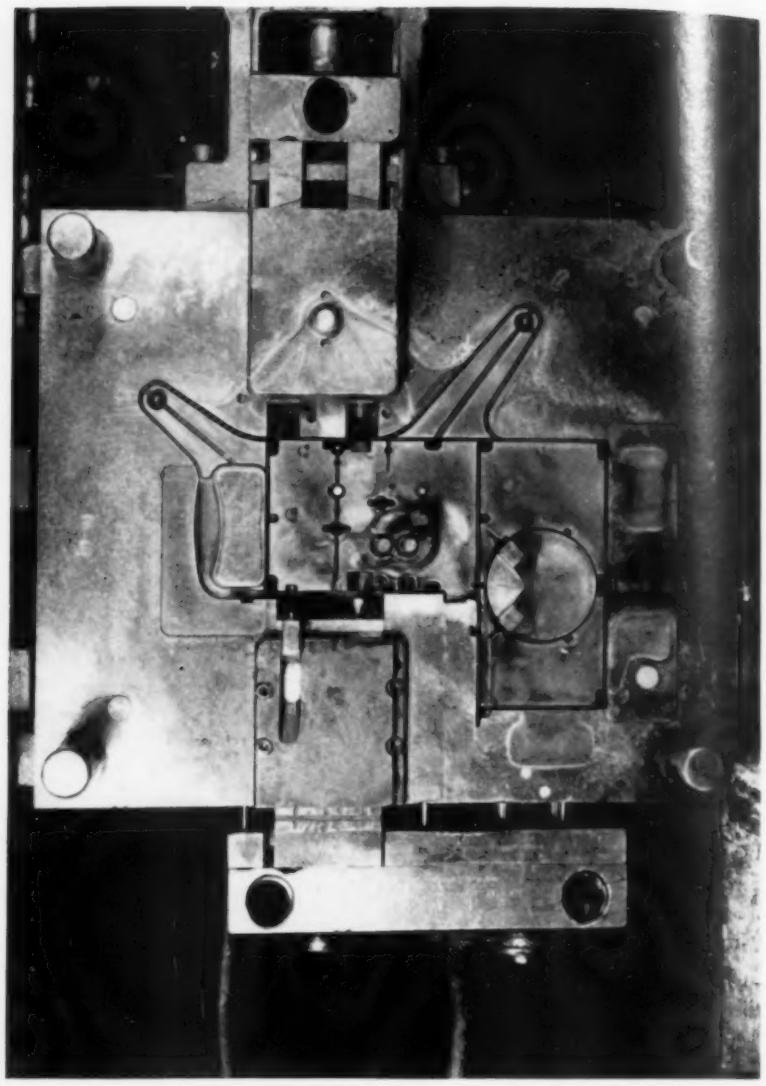
Since metallic impurities are fatal, no outside scrap of any kind goes into good zinc castings. Own scrap — that is, gates, trimmings, rejects — is ordinarily remelted in a similar alloy pot, the composition adjusted by proper additions, and checked spectroscopically for damaging elements before re-use.

In a casting machine a single-action pump is submerged in a tank of liquid alloy, its outlet connected to the cavity properly shaped in water-cooled steel die blocks. Metal is periodically replenished from the transfer car, and is maintained under pyrometric control about 50° F. above its melting point. In the photograph below the alloy pot is at the right. The three vertical bars are two tierods supporting a hydraulic cylinder (above the limits of the view) which moves the central one, the pump piston, up and down. Just left is a massive slab of metal, set vertically, which holds one half the die on its far side. Still further left and beyond the picture, in front of the operator, is the machinery for holding and moving the other half of the die — really a strong press, set horizontally; note one of the heavy tierods just in front of the operator's glove.



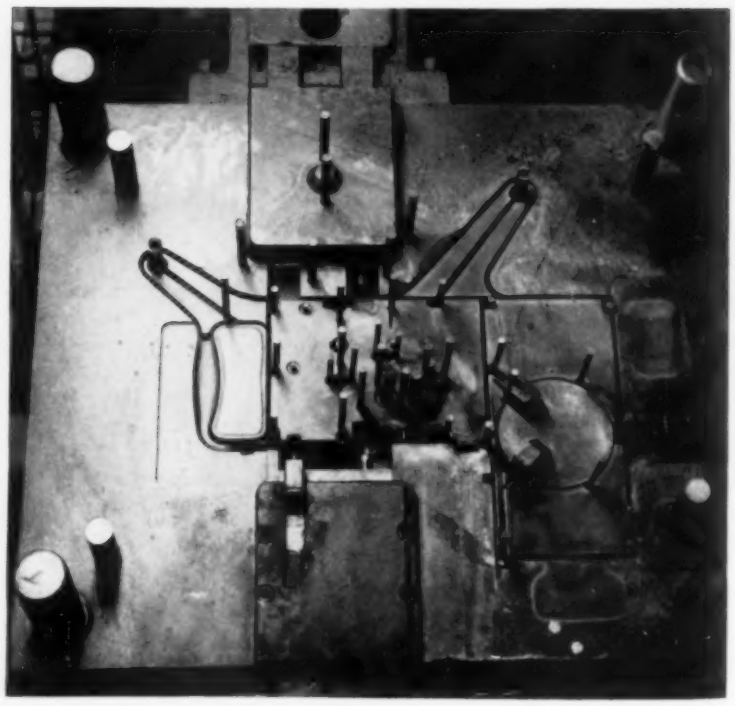
The casting cycle starts with an open die. The operator clears away any fragments of metal and brushes the cavity with a waxy solution. He trips a lever, the die closes and clamps shut. Immediately the pump plunger drives molten zinc at 2000 psi. into the cavity, completely filling it. The metal chills in seconds, the die re-opens at a set time, carrying the hot casting with it, but loosened en route by a number of ejector pins. The operator hooks the casting out, dips it into water to cool and stiffen, and the cycle recommences. About 300 an hour can be made if castings have no heavy bosses or thick sections.

Cover Half of the Die



Ejector Half of the Die

(Below) Ejector Half With Ejector Pins Protruding

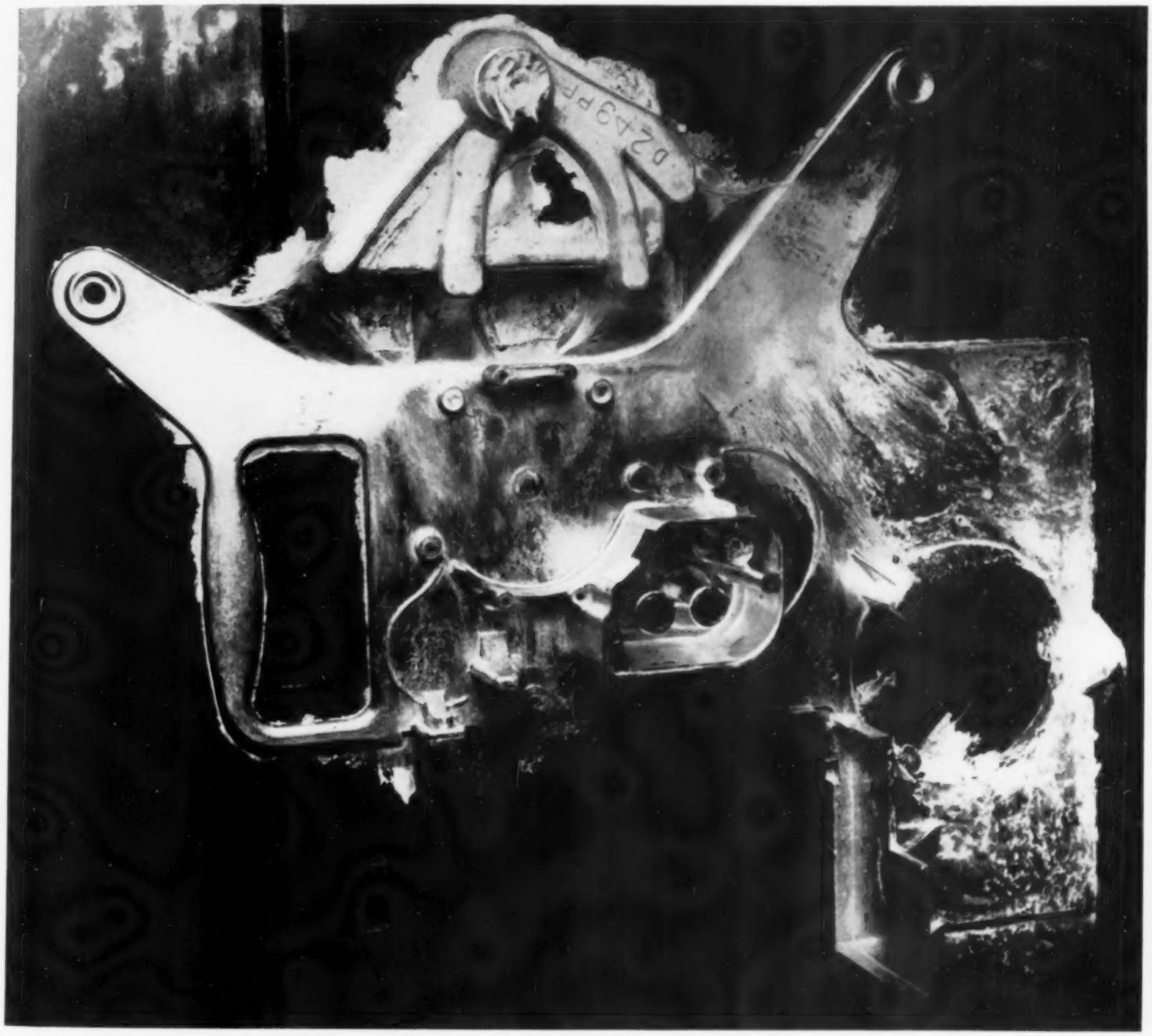


The "cover half" is attached to the stationary head of the die casting machine and usually forms the outer or exposed surface of the casting; it is drafted so the casting easily clears itself when the die opens. This cannot occur until the metal in the tapered gate chills — yet cannot be delayed, for the metal in the pipe leading to the submerged pump must always be liquid.

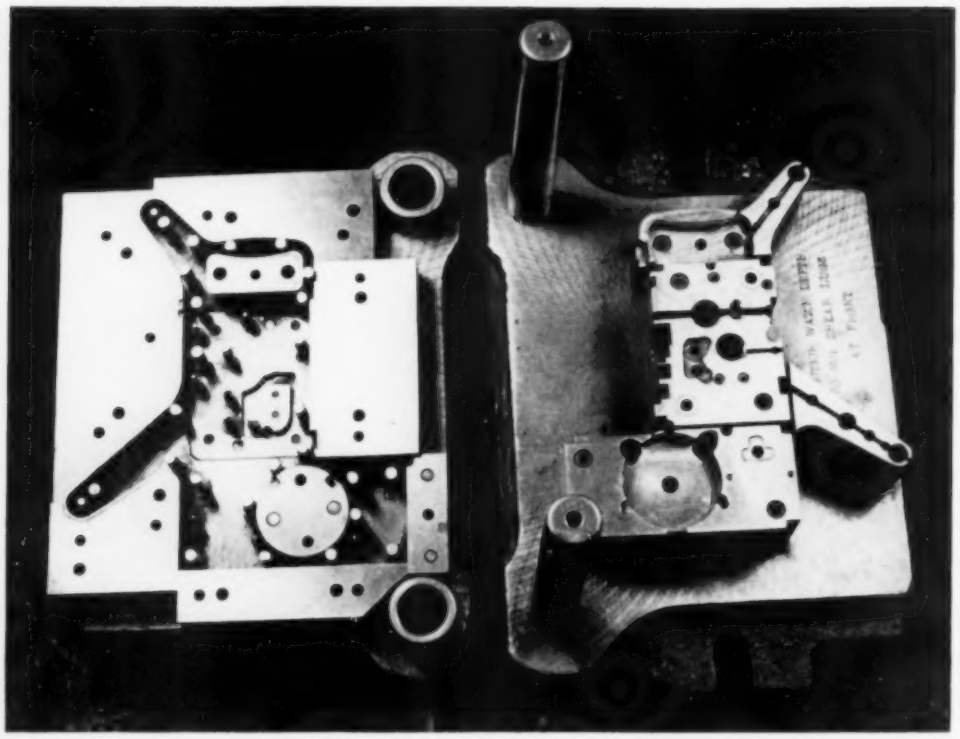
The "ejector half" is the movable part of the die. It usually forms the inside surfaces of the casting, which shrinks and sticks to the die as it pulls away from the cover. Slides carrying some undercutting cores are carried on this die, and they move in and out on stout inclined pins fixed to the cover half. Shortly before the end of the stroke, numerous ejector pins push the hot, tender casting clear of its

mold. Dies are honeycombed with waterways.

Die steels must be strong yet machinable, and able to resist rapid temperature fluctuations without cracking. Zinc alloys, melting at moderate temperatures, are easier on the dies than aluminum or copper alloys. Chromium, 5%, is the principal alloying element. Ejector pins are preferably made of cutlery type stainless steel, hardened for strength and nitrided for wear resistance.



Rush of hot metal, from gate above into furthest recesses of the mold, streaks slightly the casting's surface. Its silvery brightness magnifies these little imperfections and presents a difficult subject for the camera



Compared to the casting dies, the trimming dies are simple. Their main job is to trim off the gates and the flash, smooth the cored holes, and punch small holes as required in the thin walls. Flash along the parting line is almost inevitable, for some openings must be left in the casting dies for the escape of air ahead of the incoming rush of metal.

So little finishing is necessary on a well-made casting that the operations have come to be called "cleaning". After the fins are removed the castings are inspected visually for surface condition. Rough edges missed by the trimming die are filed. Items like carburetor bodies are given a pressure test. Porosity is determined occasionally by weighing against a standard or measuring the specific gravity. Flat surfaces may be straight-edged. Accurate dimensions stem from the accuracy of the casting die, trimming die, and jigs for any threading or boring, and need give no trouble except as the dies are worn on long runs—*accuracy*, in fact, is a prime advantage of die castings.

New Magnetic Alloy of Powdered Meta

By V. E. Legg and F. J. Given

Extracts from "Compressed Powdered Molybdenum Permalloy for High Quality Inductance Coils", Bell System Technical Journal, July 1940, page 385

"LOADING COILS" are principally used on telephonic or telegraphic circuits to reduce losses, or boost up the weakened impulses so they actuate the receiving equipment, or to reduce the distorting effect of unequal losses in the various frequencies transmitted. Cores of iron wire were first used for this purpose about the turn of the century, and these sufficed for circuits of moderate length.

With the development of telephone repeaters and the extension of circuits to transcontinental length some 25 years ago, there arose a need not only for loading coils, but also for network coils, which would have high stability with time, temperature and accidental magnetization. Magnetic stability was at first secured by employing iron wire cores provided with several air gaps. Later, commercial and technical considerations led to a core structure made from compressed insulated powdered material. This type of core is mechanically stable; it introduces in an evenly distributed fashion the requisite air gaps and avoids undesirable leakage fields, and it subdivides the magnetic material so as to reduce eddy current losses. Although other means have been suggested, no way has yet been devised which provides these features so well and at so low a cost as the compressed powdered type of core.

Cores made from electrolytic iron powder generally satisfied the stability requirements for loading coils installed on long communication lines, but on account of their low magnetic permeability they were large and costly. The search for materials with higher permeability and lower hysteresis loss led to the discovery of permalloy. (Permalloy is the name of a family of magnetic alloys, chiefly of iron and nickel. Their development is sketched in a biographical appreciation of G. W. Elmen in Metal Progress for April 1937.)

By 1925 powdered permalloy with 78.5% nickel and 21.5% iron had been compressed into cores and built into coils for voice frequency applications (loading coils and filter coils) which were cheaper and yet superior electrically to those made from electrolytic iron. These coils became available at a time when the telephone plant was undergoing a very large extension, and as a result, large economies in cost and space were realized in the more than six million coils involved.

Iron powder, and later permalloy powder, ground to a finer size and diluted to lower permeability than used in loading coils, also found application in coils for oscillators, filters and networks of multiplex carrier telephone and telegraph systems employing frequencies up to 30,000 cycles, and in receivers for transoceanic radio telephone communication employing frequencies twice as high. Permalloy powder improved the electrical characteristics — particularly modulation — of coils for use in high frequency circuits, because of its low hysteresis losses.

An improved core material known as "2-81 molybdenum-permalloy" is now available. It contains 2% molybdenum, 81% nickel, and 17% iron. In its development many problems of alloy embrittlement, pulverization, insulation and heat treatment had to be solved both on a laboratory and factory scale. It has higher permeability and electrical resistivity (essential for the improvement of coils for voice-frequency circuits) and smaller losses from eddy currents and hysteresis (necessary for economical carrier-frequency operation). It takes on considerable significance at this time because it plays an important part in commercializing the new broad-band carrier telephone systems intended for use on existing open-wire and cable lines and on new co-axial cable. Again, therefore, the advent of a new core material is well timed to be of assistance in further growth of the telephone system.

The raw materials and necessary embrittling agents are melted together and cast into ingots which are rolled to develop the desired grain structure. The brittle material is pulverized to the desired fineness and finally annealed to soften the alloy particles before insulation and pressing into core form. *(Cont. on p. 304)*

Sharp Transition From Brittle to Ductile in Hot Ingot Iron

By Matthew Charlton
Laboratory Foreman
Youngstown District
Carnegie-Illinois Steel Corp.

Mechanical tests at hot-working temperatures are very useful in discovering the best range for rolling or piercing — best as far as power consumption and tonnage production is concerned. A twist test is used by one tube manufacturer, as noted in "Critical Points" in this magazine in May. Tension tests on ingot iron, performed by Mr. Charlton, show a sharp change in its ductility at 1910° F. — curiously enough well up into the gamma range, 250° F. above the transition temperature.

CONSIDERABLE work has been done on creep testing to show the service that can be expected of steel when subjected to various temperatures for considerable periods of time. Short time tests at high temperature, however, have their place in giving valuable information as to what takes place when material is hot worked, such as in hot rolling, forging, billet piercing, or riveting. Ductility at high temperatures is important in determining the measure of the above hot working properties and as an indication of hot-short ranges.

The tests to be reported here were carried out for the purpose of determining the most suitable range for hot rolling low metalloid openhearth steel (frequently called "ingot iron"). Although the high temperature tensile test showed a very limited range of temperature in which hot rolling or any other type of hot working of a severe nature might be done with any degree of success, and therefore did not provide a great deal of practical information, it is thought that the results may have some interest as an indication of the fundamental properties of nearly pure iron.

A review of the literature relevant to high temperature testing of ingot iron did not reveal a great deal of information. However, abstracts of the most interesting and pertinent articles are as follows:

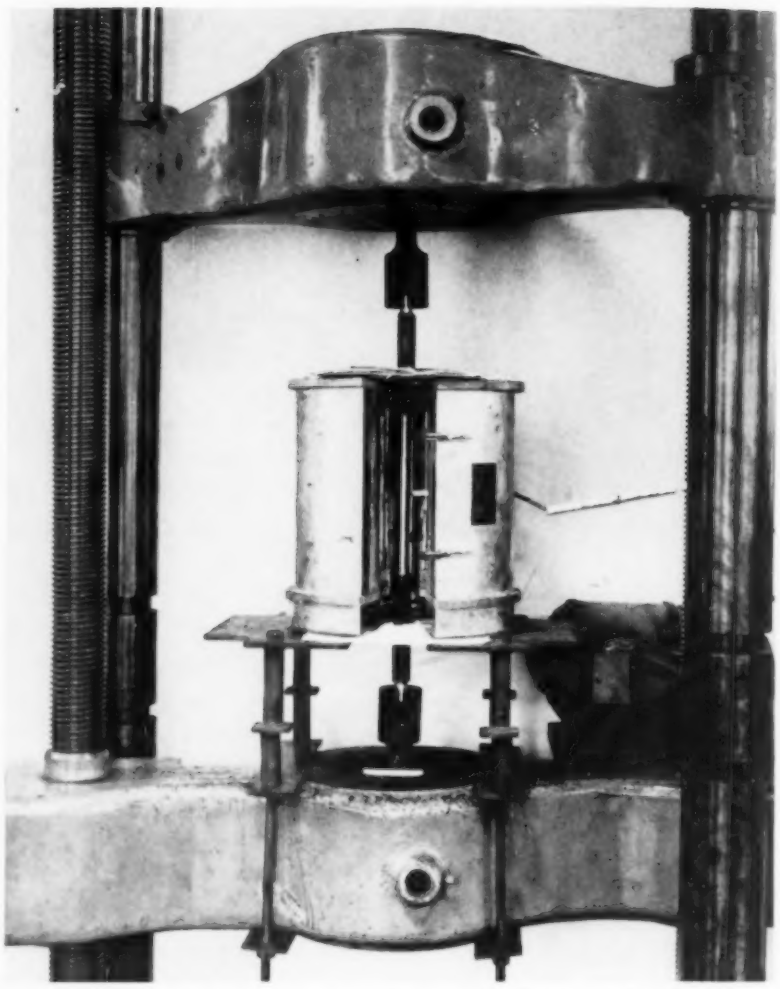
REID L. KENYON in a paper entitled "Armco Ingot Iron" in *Transactions* American Society for Steel Treating in 1928 made tests on tensile specimens from $\frac{3}{8}$-in. plate, from 75° F. to 1650° F. This work was all in the alpha phase and does not have any relation to the present experiments other than being of interest as covering, in conjunction with work described herein of results obtained in the gamma phase, the entire range of practical testing temperatures.

In a novel method of twisting $\frac{1}{4}$-in. square bars, ALBERT SAUVEUR investigated the thermal range of critical plasticity of Armco ingot iron. (Consult his Howe Memorial Lecture in *Transac-*

tions of the American Institute of Mining and Metallurgical Engineers, 1924.) SAUVEUR concluded that alpha iron at the highest temperature at which it can exist, namely, in the vicinity of 1650° F., is more plastic than gamma iron from 1725 to 1870° F. In summarizing he places the red-short range at 1650 to 1875° F. and states that the metal is very plastic at 2200° F.

These results, obtained by twisting long specimens, are somewhat similar to the present author's results but lack evidence of a sharp termination of the brittle range as was found and will subsequently be explained.

F. C. LEA also might be mentioned. In *Engineering*, vol. 113, p. 829, he gives the results of *physical* tests on ingot iron from 90 to 1830° F. which reveal that this material is within the brittle range at 1830° F.



Test Set-Up, Showing Specimen in Tensile Machine and Heating Furnace on Its Support, Prior to Closing

In the present series of tests the material was rolled to a 1-in. diameter round. The type of specimen selected as being most suitable for testing at high temperatures, considering handling and adaptability for use in our hinged, electrical resistance furnace, was 21 in. long with an 8-in. gage length turned to approximately 0.800 in. diameter. Test specimens were placed in the furnace and the furnace sealed as tightly as possible with insulating brick and asbestos paper. The specimens when heated to the desired point were held at temperature by means of a recorder-controller for 20 min. before testing. The platinum control thermocouple was inserted through a small hole in the furnace and touched the specimen at the center of the gage length.

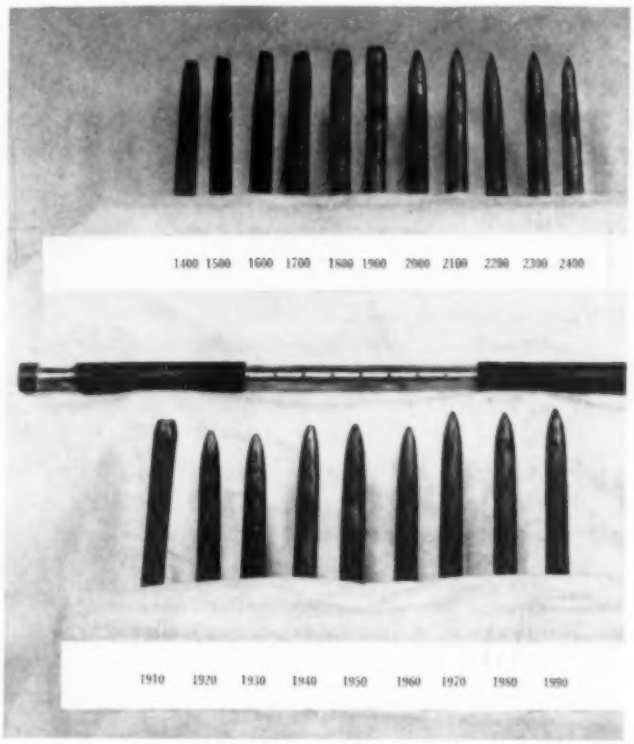
Preliminary tests were made using a bare thermocouple wire; however the corrosive action of the scale was appreciable at the very high temperatures, and contaminated the thermocouple quickly. It was then placed in a silica tube and the end of the silica tube and thermocouple welded so that only a small amount of silica covered the wire. Experimentation showed that the temperatures obtained by the covered and uncovered thermocouple checked very closely and therefore this covered thermocouple was used throughout the testing program.

To correlate closely the values obtained with the recording temperature, only the results of tests that broke within one inch of the thermocouple position were used. To obtain breakage at this position consistently, it was sometimes necessary, especially in the temperature range of 1900 to 1950° F. where there is a sudden change from maximum brittleness to maximum ductility, to taper the tensile specimens at the center as much as 0.020 in.

In order to determine the accuracy of the controlling thermocouple temperature, one specimen was drilled with a ¼-in. hole from the end to a position past the middle of the gage length. Tests made on this specimen showed the temperature on the inside to be 5° F. lower when directly opposite the outside thermocouple, 10° F. when 1 in. away, and 40 to 50° F. when 2 in. away, at furnace temperatures from 1800 to 2000° F. Considering a true temperature gradient from the center of the bar to the surface, the surface temperature would be closer to the average temperature of the cross section than the temperature 0.125 in. from the

center. Since the difference in temperature at these two points was found to be 5° F., the outside surface controlling temperature can be considered as being very close to the mean temperature at the breaking position of the hot specimen.

No consideration was given to the effect of loss of material by scaling which naturally would affect the values for unit load and reduction of area, and in increasing degree with



Original Tensile Specimen Is Shown at Middle; It Is Turned From a 1-In. Round. Top specimens tested at 100° F. intervals show a change from moderate to very high ductility somewhere between 1900 and 2000° F. Lower row tested at 10° F. intervals locates this change between 1910 and 1920° F. for this particular heat of ingot iron

increasing temperature. One test specimen was measured to give some idea of the amount of scale, and showed a loss of 0.036 in. in diameter after being at temperatures from 1800 to 2000° F. for 4 hr. — approximately six to eight times the time the specimen would be at any one of these temperatures for actual testing conditions. It might be mentioned that very little scale flaked off during the heating period; the scale closely adhered to the test pieces, and after testing — especially at high temperatures — separated from the specimens in concentric collars or sleeves.

When testing the specimens a crosshead speed of 5 in. per min. was used to eliminate, as far as possible, loss of temperature from disarranging the packed insulating material and from pulling the center of the specimen (by elongation of the specimen) towards the colder end of the furnace.

Metal from four heats of ingot iron was tested. Check analyses of the material are given in the adjoining table. The zeros for chromium, vanadium and molybdenum indicate no measurable result in the standard quantitative analysis used by U. S. Steel Corp. chemical laboratories. It will be noted that Heats A and B are copper bearing.

Check Analyses

Heat Mark:	A	B	C	D
Carbon	0.03	0.03	0.03	0.03
Manganese	0.04	0.06	0.04	0.06
Phosphorus	0.008	0.008	0.008	0.009
Sulphur	0.041	0.035	0.036	0.030
Silicon	0.001	0.002	0.003	0.002
Copper	0.23	0.28	0.01	0.01
Chromium	0	0	0	0
Nickel	0.01	0.01	0.01	0.01
Vanadium	0	0	0	0
Molybdenum	0	0	0	0

Tests were run at 100° intervals from 1400 to 2400° F., inclusive, and at 10° intervals in the brittle range from 1900 to 2000° F.

Few check runs were made at the 100° intervals. The trend was merely established but showed good agreement for the four heats. However, numerous tests were made at 10° intervals to determine accurately the sharp termination of the brittle range.

Results for Heat D are shown graphically in the charts on the next page. The original test piece and some specimens after testing are also shown in the halftone at left.

The four heats, although showing a quite similar trend of increasing brittleness with increase in temperature, reveal a slight difference in the end of the brittle range as follows:

	End of Brittle Range
Heat A	1940° F.
Heat B	1910° F.
Heat C	1930° F.
Heat D	1910° F.

The tensile strength increases slightly as the temperature rises from 1600 to 1900° F., while the elongation and reduction of area gradually decrease. A sharp increase in the elongation and reduction of area terminates the brittle range, and the tensile strength from this

point decreases gradually with increasing temperature.

Heats A and C have similar values for the end of the brittle range while Heats B and D are similar and somewhat lower. Reference to the analyses shows that copper has no effect; the differences noted are possibly due to relative manganese and sulphur content. The two heats showing the lower values for the end of the brittle range have a higher manganese content but approximately the same amount of sulphur as the other two heats.

Conclusions

Stating the *range* of temperature for brittleness does not give sufficient information as to the hot workability of this material. Starting from the lower temperatures investigated, the increase of brittleness with increase in temperature was gradual. At the end of the brittle range, the change to increasing ductility was found to be sharp.

A slight difference in the temperature at which brittleness ends was found for the several heats, and possibly is due to the amount of manganese present or more probably the manganese to sulphur ratio. Of four heats tested that had approximately the same sulphur content, the two that had the higher manganese had the lower brittleness end point temperatures. Copper addition apparently made no difference.

In the brittle range, while ductility decreased, tensile strength increased slightly with increasing temperature.

Soft Soldering

By J. L. Miller

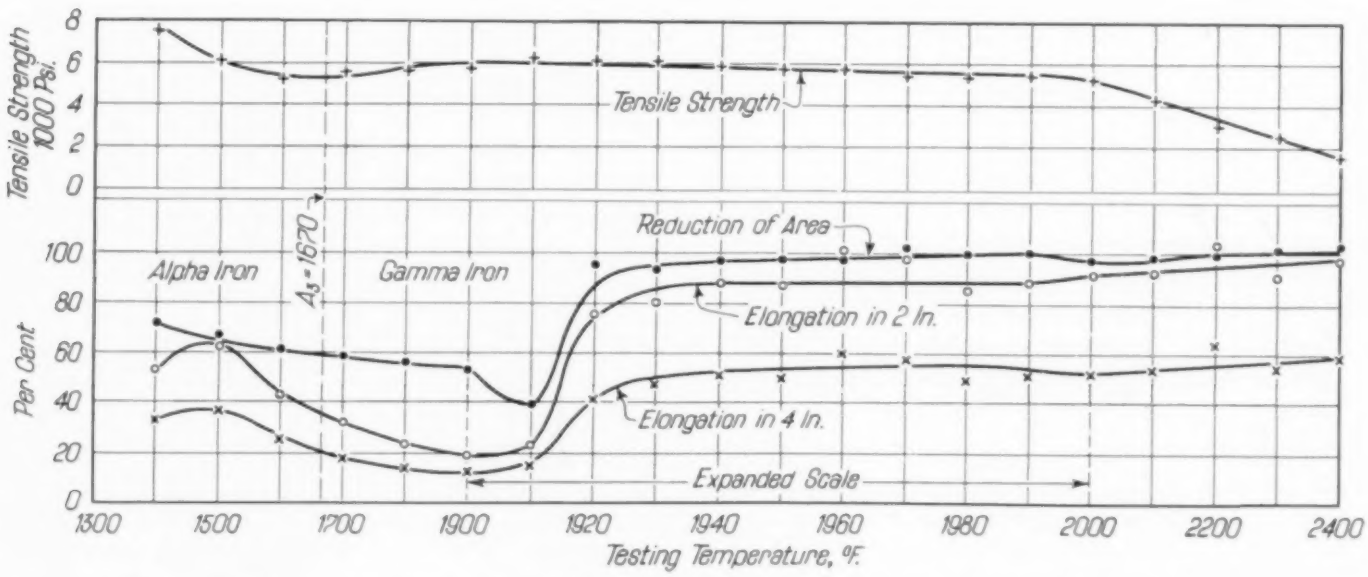
Abstract from *The Metal Industry*, Aug. 2, 1940, p. 82

WHILE the art of soft soldering is many centuries old, and today is the chief reliance of a tinker, it is largely used in modern production processes. Some interesting mechanical aids have been developed — for example, the automatic soldering of side seams on tin cans.

Soft solders are usually binary alloys of tin and lead. Some solders also have antimony. Tin is so expensive that solders are among the dearest metals used in any quantity, so the methods used should result in the minimum of waste. The engineer has a wide range of compositions to choose from, and his choice is determined by *(a)* the melting point and solidification characteristics required, *(b)* the method of application, *(c)* the cost of the solder, *(d)* the time to make the joint, and *(e)* health considerations; solders in contact with food stuffs should contain as little lead as possible.

Composition — As is well known, lead and tin form a eutectic melting at 360° F., and all solders containing 20% or more tin start to liquefy at this temperature. Workers on ordinary sheet metal require a free running solder (short range between eutectic and liquidus) and prefer an expensive 50-50 lead-tin solder. A wider mushy range is required for a plumber's wipe joint, so the solder used has about 30% tin.

As soldered joints have frequently to work at temperatures unsafe for ordinary *(Cont. on p. 306)*



Tests Made at 10° Intervals (Note the Expanded Scale Between 1900 and 2000° F.) Show That the Transition From Brittle to Ductile State in Ingot Iron is Very Sharp

Correspondence and Foreign Letters

No Mystery in Arc Welding

EDITOR'S NOTE — A letter from JAMES F. LINCOLN was printed under the above title in the April issue of METAL PROGRESS which brought forth a rejoinder from W. J. CHAFFEE in August to the effect that "Arc Weldors Must Be Qualified". Mr. CHAFFEE's letter was sent to Mr. LINCOLN prior to its publication, but the following closure — written by an associate — was received too late for the August issue.

CLEVELAND, OHIO — It seems to me that Mr. CHAFFEE, in his recent letter, has entirely missed Mr. LINCOLN's point.

It is generally recognized that only a comparatively small amount of welding is being done which can and should be done. This means there is a vast amount yet to be changed to welding. Since this is true, it is quite obvious that there are jobs waiting for thousands, yes tens of thousands, of weldors in the future.

Why doesn't this tremendous amount of welding with its thousands of jobs develop more rapidly? Well, partly because of tradition and largely because the progress of welding is being held back by every kind of law, code, rule and restriction, made and passed by Societies, City Councils, State Legislatures, Federal Authorities and any one else that cares to. Every one seems to have a hand in formulating rules covering welding. The unfortunate part about this is:

I. Many rules, codes, and the like are unduly restrictive, and what is permitted in one code is restricted or forbidden in another.

II. The cost of welding, due to tests and unnecessary restrictions, is in many cases increased to the point where it is uneconomical and cannot compete with other methods.

Why do we have this more or less chaotic condition? Because the public has been led to believe that welding is something mysterious, that requires that the Good Lord must come down and personally supervise each weldor and his work. Such is furthest from the truth! Everyone who knows welding knows that a good weldor (note, I say *"good weldor"*) furnished with proper material and equipment will consistently make welds that are stronger than the material being welded.

Is the trained riveter beset by checkers and inspectors on every rivet he drives? Is the trained machinist harassed by supervisors on every operation of his lathe? Do we X-ray every casting that is used?

We do not mean by this that really necessary precautions for safe, reliable welding should be eliminated. The point we are hoping to make is that the weldor is not being given a break. We are not in any way trying to cast a reflection on him, as has been implied. What we are trying to do is to get the same acceptance for his work that is given to a riveter, a machinist and other recognized trades. When that is done, the scope of welding will broaden tremendously and the call for weldors will be far greater than the supply.

We say in our "Lessons in Welding", used in our own and many other schools: "The Lincoln Electric Co. is interested in the weldor and is doing everything possible to help him increase

his knowledge of, and skill in, welding". We do believe that good weldors consistently produce good welds and that you don't have to pass laws to have him do so.

A. F. Davis
Vice-President
The Lincoln Electric Co.

Use of Clad Metals in Germany

Letter to Metal Progress by
W. Rädeker
Research Laboratory
Deutsche Röhrenwerke Thyssen

Mülheim, Ruhr, Germany — In recent years great efforts have been made to improve the manufacture of coated material or clad metal — that is, to bond a noble metal as a coating on a steel base — and to widen the field of use, particularly in the chemical industry. Two reasons are particularly important: Foremost is the desire to spread the available amount of strategic metal over the widest field of use, particularly in view of the growing demands of the chemical industry. Furthermore, clad metals have additional properties they do not in themselves possess. In general, the following advantages may be said to result:

Copper coated sheet has a higher tensile strength than solid copper, particularly at elevated temperatures. For the same working load it is lighter in weight. Furthermore, welded joints in copper coated sheet withstand stress better than in plain copper.

In nickel coated materials the advantages of better high temperature strength and weldability, together with the price advantage, are noteworthy.

Sheet coated with 18-8 chromium-nickel steel, in addition to the saving in alloying metals, possesses the great advantages of higher thermal conductivity, better weldability and workability.

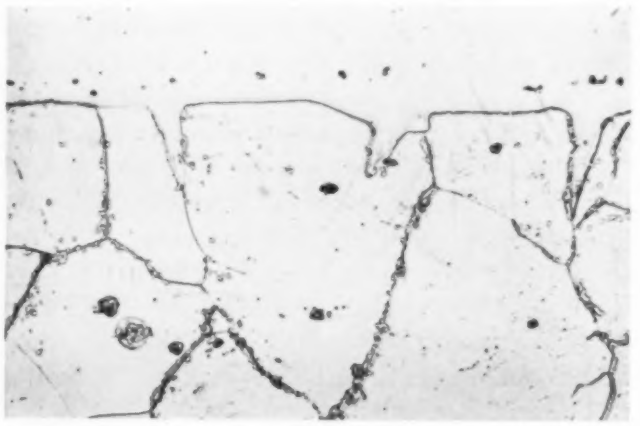
Steel sheet coated with silver has better weldability than solid silver, higher strength at high temperature and, above all, lower cost. The economic and engineering advantages of clad metals are well exemplified by it.

Furthermore, it is possible to bestow additional desirable properties on the base metal by using alloy steel. Thus, instead of the ordinary steel of 57,500 psi. tensile strength, a scale and creep resistant steel or one with special electrical properties can be used. The result is that coated metals have often been used where the materials formerly used did not serve satisfactorily.

The most common method of manufacture is by rolling the pair at the welding temperature. Steel can be bonded in this manner to nickel, to copper and copper-nickel alloys such as monel metal, to stainless steel and to silver. Steel and stainless steel can also be bonded by a duplex casting process. Steel and aluminum can only be joined in the form of previously rough rolled sheet or strip. This method is complicated and is not yet in commercial use for chemical apparatus.

It is believed that adhesive strength is now sufficient for all requirements of fabrication and later operations. This was demonstrated primarily by means of laboratory tests such as bend, torsion, tension and repeated stress tests. Likewise metallographic examination gives convincing evidence of the quality of the bond. The adhesive strength at high temperature is checked by means of repeated quenching.

Recently a method for evaluating the adhesive strength has been devised in the test shown in the halftone on the next page. The coated layers are soldered together and welded to a prolongation of the iron base. This is then



Soft Steel (Below) Coated With Stainless Steel. The close bond of the coated metal to the base metal is clearly shown. 500 ×

shaped up and used as a tensile test specimen.

The following are the minimum values for adhesive strength which have been determined for various coatings on mild steel:

Silver	21,000 psi.
Copper	28,500 psi.
Nickel	34,000 psi.
18-8 stainless	35,500 psi.

Since chemical stability of the coating may deteriorate by diffusion of the base metal, by contact with the furnace atmosphere, or by internal stress caused by uneven coefficient of thermal expansion, this must also be verified. However, perfected methods of manufacture now endow the metal coating with the same immunity to chemical attack as though the material were solid.

Welds in coated metals completely satisfy the requirements of tightness, mechanical strength and chemical stability. In general, the base metal is electric arc welded using covered electrodes, a type of welding that insures structural safety. The seam is then thoroughly cleaned and the coated side finish welded using the coating metal. The following welding methods are preferred:

Copper — gas welding for thin surfaces; electric for thick surfaces.

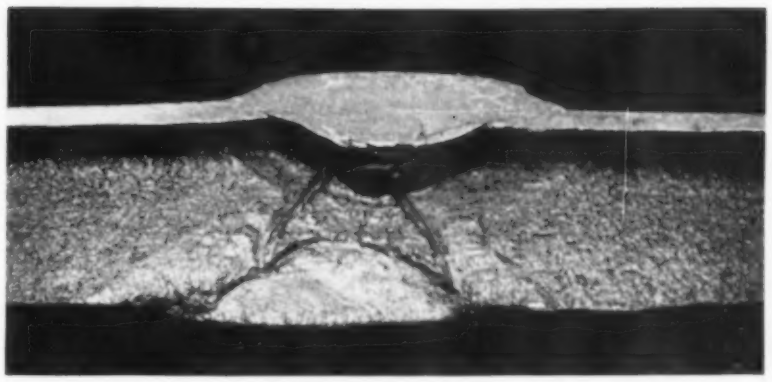
Silver — gas welding.

Nickel — gas or electric welding (at present the latter seems to be favored).

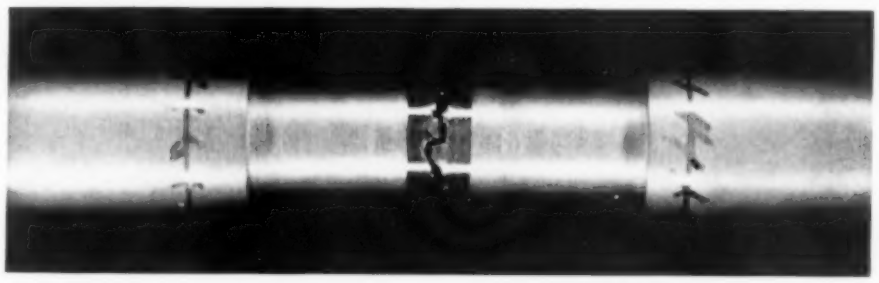
Stainless steel — electric.

Non-destructive testing of the welded seam is done by X-rays. Otherwise the tensile properties and structure of the seam are tested by the ordinary bend, tensile and micro specimens.

The following test provides a good indication of the chemical stability of the seam: A sample such as used for metallographic examination is immersed for at least ten days in a normal HNO_3 solution. The varying degree of attack on steel base and metallic coating is clearly shown, as can be seen in the halftone at the top of the page.



Welded Nickel Coated Test Piece After 10 Days in 1N HNO_3. The base metal is strongly attacked by the acid, while the coating and its weld are untouched. 4 ×



Full-Size View of Test for Determining the Adhesion of the Coated Layer

Exhaustive investigations in this direction, as well as practical observations, lead us to the conclusion that welded joints in coated sheet made in ordinary manufacturing operations now possess the same chemical and mechanical stability as the unwelded sheet. Satisfactory operation of welded apparatus made of coated material is therefore warranted.

It might also be mentioned that bi-metal plate has recently been used for heavy duty bearings; indeed the proposal to shrink the steel supporting box on the bearing metal is not new. This, however, had the great disadvantage that because of the heterogeneous microstructure of the bearing metal it will not adhere or weld with the steel backing very well, and heating of the bearing due to heavy work or inadequate lubrication will loosen it from the supporting base and it is soon destroyed. Present practice, however, is to bend the coated plate into a bearing and then with a special supplementary metallurgical treatment secure the desired anti-friction properties. Their advantage is an uninterrupted outflow of heat.

Coated sheet has a wide range of useful possibilities in chemical apparatus not feasible with solid materials, and its use in Germany is constantly becoming better established in various other applications.

W. RÄDEKER

Converter Steel for Shrapnel Shells

Letter to METAL PROGRESS dated July 22, 1940
from Prof. ALBERT M. PORTEVIN
Consulting Engineer; Bessemer Medalist

ANGOULEME, FRANCE — Mass production of explosive shells has reflected upon the methods for the steel making. (We will consider here only the somewhat thin-walled explosive shells, rather than the hard-tipped and thick-walled armor-piercing projectiles.)

If we go back to 1914, before the first war, explosive shells made of semi-hard quenched steel were obtained from acid Martin steel (acid openhearth) and came almost exclusively from steel works renowned for the uniformity of their product. This uniformity, as well as the great pains taken to eliminate physical defects — in other words, the quality of the steel — greatly simplified the heat treatment, which was done in a few military establishments according to tradition.

However, it soon became necessary to resort to basic Martin steel (basic openhearth) originating not only from a number of French plants but also from various countries, particularly the United States. Moreover, shells had to be produced in a great many factories which had no experience in that sort of work. Difficulties in fabrication, particularly in heat treatment, were therefore considerably increased, but they were solved by study and improvement in the methods of hardening and control so that finally, in spite of the difficulties and the increased production, a very small proportion were rejected.

In the end, Thomas or basic converter steel was also used to a certain extent, especially by the Germans for their thick-walled projectiles since they could use the high phosphorus Lorraine ores. For this purpose it was necessary to produce a somewhat harder type of Thomas steel than the varieties usually employed for metallic construction, and at the same time improve its quality.

The problem of producing hard rails of Thomas steel, which was solved somewhat later, contributed to this project in that it adapted to every-day fabrication a series of classical precautions used for quality steels with a view to improving their compactness, homogeneity, quality and uniformity of surface. Compactness is improved by avoiding blowholes, by killing the steel with silicon, and eliminating secondary pipe by tapping into big-end-up ingot molds, using a hot top if necessary. Soundness and uniformity are insured by care in deoxidation and casting so as to avoid any slag reaction in the ladle and irregular distribution of addition elements. Good surface quality is secured by slow pouring into the ingot molds, which should be in good condition and of proper shape, and by careful chipping of defects either in the ingot or bloom.

Thomas converter steel may thus be perfectly suited to the manufacture of explosive shells, a fact that demonstrates the great progress made in 25 years since the beginning of the previous war. Another result is the release of the other steel making processes to be used for other purposes, thus increasing their production as well. Moreover, we must not forget that the modern Ugine-Perrin process for refining of steel, which we have already described (Duplex Refining Process, METAL PROGRESS, Feb. 1934, p. 40) now permits of rapid, quantity production, from the Thomas converter, of high quality steels and alloy steels.

ALBERT M. PORTEVIN

Mixture of Bakelite and Metal Powder for Mounting Micro Specimens

Letter to METAL PROGRESS
By NORMAN J. FINSTERWALDER
Metallurgical Dept.
Taylor Instrument Companies

ROCHESTER, N. Y. — The introduction of plastics as a material for mounting micro specimens for subsequent polishing and etching has brought about the problem of making an electrical contact with the specimen when it is desired to etch or polish electrolytically.

One procedure has been to solder all the specimens to be placed in one mount to a soft stainless steel wire approximately 0.015 in. diameter. By forming a helical coil with two or three inches of surplus wire and standing it upright in the mold, the end of the wire will be at the top surface after mounting. With extremely small specimens this method cannot be used and with larger specimens the procedure is tedious and time consuming.

Mixing a suitable metallic powder with bakelite powder and then molding in the same manner as with bakelite alone, results in a conductive mount. Consequently specimens of any size can be mounted with this mixture and

an electrical contact will thus be made between each one and the outer surface. The specimens can then be etched by grasping the mounting with a suitable metal clip which is connected to one pole of the circuit.

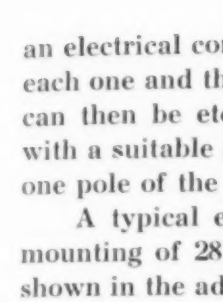
A typical example of the foregoing is the mounting of 28 specimens of 19-9 capillary, as shown in the adjoining photograph. It is essential that the bore of each one of these specimens be filled with the mounting material to eliminate burring due to subsequent polishing. To insure penetration the specimens of capillary tubing are cut only $\frac{1}{16}$ in. long.

The grinding and polishing characteristics of bakelite mountings are not materially affected by the addition of the metallic powders. The tendency to stick to the mold is reduced.

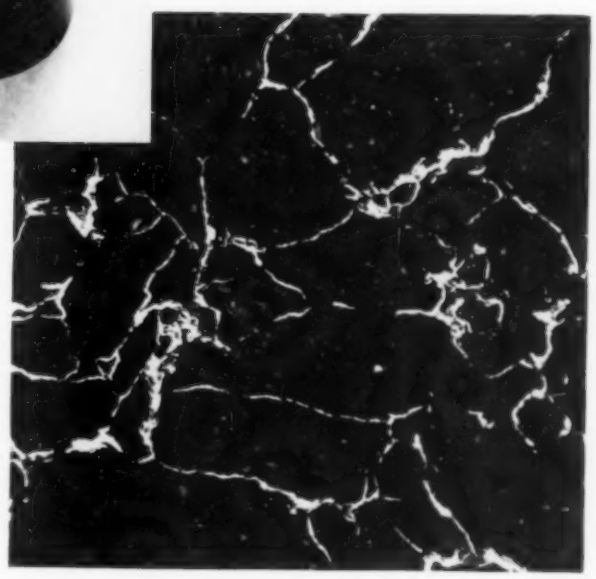
The metallic powders found satisfactory have a particle size such that approximately 90% will pass through a 140 mesh and 50% through a 200 mesh screen. Copper and aluminum powders have been most satisfactory. From 10% to 20% by weight is used of the copper powder. Approximately half of this percentage is sufficient if aluminum powder is used. When thoroughly mixed with the bakelite each particle of bakelite becomes coated and after molding a metallic network is produced as shown in the photomicrograph. The outside of the mounting has a metallic appearance and electrical contact is readily made with the supporting clip for etching. Aluminum has an advantage, when etching reagents requiring a considerable length of time are used, in that it is but slightly attacked by the etching reagents.

When using the foregoing technique for the electrolytic polishing of specimens, it must be borne in mind that perchloric acid solutions must not be used due to the explosion hazard which arises when bakelite and perchloric acid are brought together.

NORMAN J. FINSTERWALDER



Stainless Steel Capillaries (0.008-in Bore) Mounted in a Mixture of Bakelite and Copper Powder. Mounting material must fill bore



Photomicrograph at 50 Diameters Showing Network of 20% Copper in Bakelite, After Molding and Curing

Protective Coating Sprayed on Aluminum Castings

Letter to METAL PROGRESS
By R. M. MAJOR
Metallurgist; Servel, Inc.

EVANSVILLE, IND. — Protection of the bare metal parts of an evaporator unit in a domestic refrigerator is an important problem. Such units in Servel refrigerators contain some aluminum castings, sheet and extrusions, and the bare metal takes on an unsightly appearance from the condensate, ice and liquid during the cycles of freezing and defrosting.

For protection aluminum castings were dipped in molten paraffin held at a temperature of 300° F. Since the dipping was done while the castings were on a conveyor, the tank had to be long and, therefore, held a large volume of wax. Odor was a serious problem so that specifications were very rigid and inspection careful and extensive. In spite of the fact that the temperature of the molten wax was closely controlled, it very easily became contaminated, so that it was necessary to take daily checks on color and odor.

Drag-out had to be replaced by new daily additions. While this fresh material helped to maintain the purity of the tank, even under the best conditions the entire tank had to be emptied every three weeks which, of course, meant a loss of several tons of wax. Floor space taken up by the long tank, together with the additional drain boards, was an important factor. Fire hazard was also an important consideration because the

wooden floor in the vicinity was soaked with wax and, finally, holding the wax in a molten condition was both expensive and hazardous.

While all of these points rendered the dipping process unsatisfactory, the most important disadvantage was the fact that with every precaution it was still felt that the odor was not completely eliminated. We therefore decided in the chemical laboratory to develop an emulsion of wax, or a combination of waxes which could be sprayed on and would be odorless and give satisfactory protection.

In working out the formula for such an emulsion, a number of points were considered:

In the first place, it was felt desirable to incorporate some wax or wax-like material which would have great adhesion and flexibility at zero temperatures. It would also be advisable to have an amorphous wax to fill up the voids between the microscopic crystals of paraffin that would form. This would give a much denser coating which would not only be considerably more waterproof, but which would also be more durable.

The correct choice of emulsifying agent was also a very important factor, as it was necessary to be viscous enough for spraying, form a stable emulsion that would not separate when standing in reserve stock, and which would not cause an abnormal amount of foam when sprayed. It should also dry quickly and produce no flammable vapor. The coating must finally be dense, continuous, colorless and odorless.

The amorphous wax and the emulsifying agent chosen are the first and second items of the following formula, and both are proprietary articles manufactured by Glyco Products Co.

Flexo wax "C"	2 parts
Diglycol stearate "S"	1 part
Paraffin wax	4 parts
Distilled water	40 parts

This emulsion has given very good protection to aluminum castings and to extruded parts and alumilited sheets. It has also been found very satisfactory in protecting zinc and tin plated parts from finger printing while passing from the plating room through various processes of assembly.

Its use has resulted in numerous advantages. In the first place, because of the fact that spraying is easily controlled, there has been considerable saving in material. Labor has been saved because of the ease of handling a cold liquid, as compared to handling of solid wax and its subsequent melting. Odors have been eliminated due to the elimination of melting and remelting. The finished work is superior to that obtained by the hot dip process. The daily control tests on the molten wax, and of the intervals of draining and cleaning the tanks have been avoided. A considerable amount of floor space has been saved. Because spraying is a cold process, the steam formerly required to keep the wax in a molten condition has been saved as well as watchman's time during periods when the tanks were not in use.

Better working conditions prevail by eliminating the heat radiated by the hot wax in summer. Furthermore, it was practically impossible to overcome the slipperiness of the floors due to wax drip after the work left the drain board. Fire hazard has been reduced to zero.

Finally, the dipping method gave a superfluous and uneven coating of solidified wax, whereas spraying the emulsion means applying a controllable amount of wax by air pressure which drives the emulsion into surface irregularities on the metal. As soon as the water has evaporated, a uniform protective coating of wax is left.

R. M. Major

Another Ghost

An Adult Dodo Bird Found in a Cadmium Alloy (10 ×) by Henry Aughey. Courtesy of the DuPont Experimental Station

Energy Losses in Impact Testing

Letter to METAL PROGRESS
By N. DAVIDENKOFF
Professor, Physico-Technical Institute

LENINGRAD, U.S.S.R. — An interesting fact about impact testing machines has been discovered by G. ZAITZEV of the Zaporosh steel works in the use of three different machines of the pendulum type supplied by three different firms. Extended tests of a given heat of steel (20 to 25 samples) were made in each machine, and he found that there was a consistent difference in the results.

The three machines were the Amsler of 15 kg-m. capacity, the Losenhausen of 10 kg-m. capacity and the Schopper of 30 kg-m. capacity. Average results on Steel A are:

Amsler
5.32 kg-m. per sq.cm.
Losenhausen
6.28 kg-m. per sq.cm.
Schopper
6.68 kg-m. per sq.cm.

Thus the Losenhausen machine gave a result that was 18% higher than the Amsler, and the Schopper 25%.

Izod Impact Machine for Plastics and Condensation Products Designed by Bell Telephone Laboratories

In view of the evident discrepancy (25%) which cannot be put down to experimental errors, the "machine equation" should be given special attention. ZAITZEV is inclined to connect the possible sources of error with the energy of rotation of the pendulum, which at the moment of impact is spent on bending the rod which suspends the pendulum; a slender rod will involve high energy losses which are obviously unrelated to the specimen. This rotational energy constitutes part of the total energy of the pendulum, being equal to the ratio of the distance between the center of oscillation and the center of gravity to the length of the pendulum (referred to the center of percussion). The highest losses will therefore correspond to short pendulums having slender rods and high moments of inertia. A systematic investigation of this problem has been started at the Kiev Institute of Applied Mechanics.

Another fact to be considered when using impact machines of the pendulum type, is the error connected with the determination of the energy absorbed by brittle materials. Extremely small amounts of energy of the order of 0.5 to 1 kg-m. are spent in such instances, the greater part of the energy being wasted on secondary losses, so that the values of the energy absorbed cannot be used for characterizing the quality of the material tested. This becomes especially pronounced when plastics (condensation products) are submitted to impact tests, since most of the energy is then spent on accelerating the fragments. Attention was already drawn to this fact by W. A. ZINZOW at the annual meeting of the American Society for Testing Materials in 1938, in the course of a discussion of a paper on "The Impact Testing of Plastics" by ROBERT BURNS and WALTER W. WERRING. The subject was touched upon independently by B. PINES of Kharkov, who compared the energy spent on the rupture of ceramic specimens in a static bending test, with that recorded by the impact pendulum. The results of this comparison for four different mixes of clays are:

Energy Absorbed in Kg-M. per Sq. Cm.

STATIC TEST	IMPACT TEST
0.037	0.77
0.033	0.51
0.0103	0.50
0.0314	0.62

The true energy absorbed is thus seen to constitute only 2 to 5 % of that recorded by the impact machine.

In the case of unnotched steel specimens showing a brittle fracture at liquid air temperatures, a simple calculation suffices to show that the figures obtained with an impact machine are also up to ten times higher than the true values.

N. DAVIDENKOFF

FOUR BIG REASONS For Advertising In October Metal Progress

1 **Cover the Metal Show,** the most important event of the year in the metal producing and fabricating industries. Metal Progress is published by the sponsor of the Show, the American Society for Metals. It will carry the Official Preview to *all* ASM members—more than 11,000—before the Show and will be distributed from Official Headquarters at the Show itself.

2 **Eight-magazines-in-one.** This October issue will have editorial and advertising pages classified into the following eight sections. Your advertising will get a break in a good position alongside related editorial material.

(1) Non-Ferrous Metals
(2) Heat Treating & Finishing
(3) Testing & Control Instruments
(4) Steels & Irons
(5) Forging & Metal Working Machinery
(6) Furnaces & Refractories
(7) Heat & Corrosion Resistant Metals
(8) Welding & Cutting

3 **Engineering Data.** Metal Progress will again present its noted collection of tabulated engineering data sheets. These valuable reference sheets have made this October issue a preferred book on every metal man's desk. (Single copy price—$2.00)

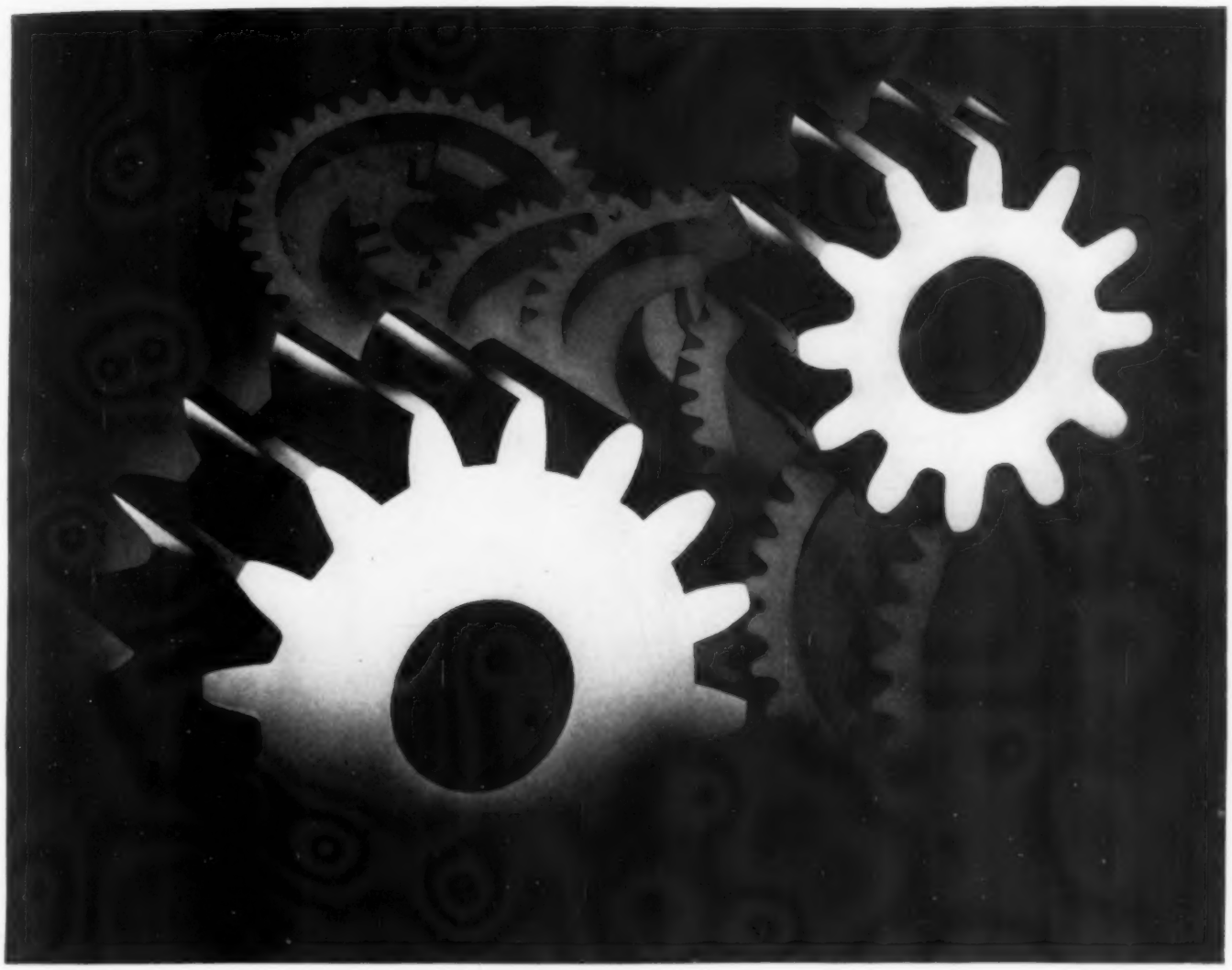
4 **Defense Aids.** In addition to all other regular editorial material, Metal Progress will show how each branch of the metal industry will be able to lend aid or develop new aids to the defense program, reaching into new and higher levels of production, product and quality. This will be timely, authoritative material of interest to every metalist.

You still have time to get one of the better locations for your advertising in this important issue. Reserve some space now. You will get more for your money in this October Show issue of—

Published by
American Society for Metals

METAL PROGRESS

7301 Euclid Avenue
Cleveland, Ohio



GETTING THE JUMP ON MAINTENANCE

There are two kinds of deferred maintenance on heavy duty equipment. One is simply that the operator has a way of letting things go until major, and expensive, repairs are unavoidable. The other is due to the inherent ability of the machine to run for long periods without requiring maintenance.

Manufacturers reduce the effects of operating wear and tear by building modern materials into their machines at vital spots. Thus, for example, a builder of heavy duty material handling equipment for mines uses Nickel-Molybdenum (SAE 4640) steel for the all-important drive gears.

The steel can be oil quenched and drawn to produce a hardness from 400-450 BHN combined with excellent strength and toughness. Thanks to the combination, the gears operate for years under all sorts of adverse conditions.

Practical data on 4640 and other Molybdenum steels are given in our book, "Molybdenum in Steel," a copy of which will be sent to you free on request.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

MOLY

Personals

W. G. Sonderman, for the past 20 years in the Cleveland branch of Columbia Tool Steel Co., has been appointed manager of the Cincinnati branch.

Davis D. Wilson is now employed in the engineering department of Oil Well Supply Co. in Dallas, Texas.

Leon B. Rosseau, formerly industrial heating specialist for General Electric Co., is now district sales manager for The Ajax Electric Co., Inc., Philadelphia.

D. W. Murphy is leaving the department of engineering research of the University of Michigan to join the staff of the development and research department of the Bethlehem Steel Co., Bethlehem, Pa., as research engineer.

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—AND BY ANY YARDSTICK
Stuart's
Cutting, Grinding
Deep Drawing
OIL PRODUCTS
SAVE MONEY FOR USERS!
Products that are original and different plus modern sales engineering total a service worthy of investigation by every economy-minded plant executive.
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Error to be Corrected: The personal item on page 190 of last month concerning **Harold P. Bristol** was something less than accurate, and stems from an old and uncorrected error on our membership records confusing him with **Howard H. Bristol**, president of The Bristol Co., sustaining member. The item should have read:

"**Harold P. Bristol**, vice-chairman, New Haven Chapter, formerly foreman of the hardening room, The Bristol Co., is now sales engineer for Crucible Steel Co. of America in New Haven. His former position is being filled by **M. Churchelow**."

Apologies are due Messrs. Bristol, Bristol and Churchelow.

R. M. Gibson has severed his connections with the Burlington Steel Co., Ltd., of Hamilton, Ont., and has accepted a position with the British Supply Board, for service in the United States and Canada.

Daniel P. Dyer, Jr. has been transferred from the Worcester district, American Steel & Wire Co. as research engineer, to the Cleveland plant as engineer in charge, vibration fatigue laboratory.

John C. Barrett is now metallurgical assistant to the engineer of tests, Baldwin Locomotive Works, Eddystone, Pa.

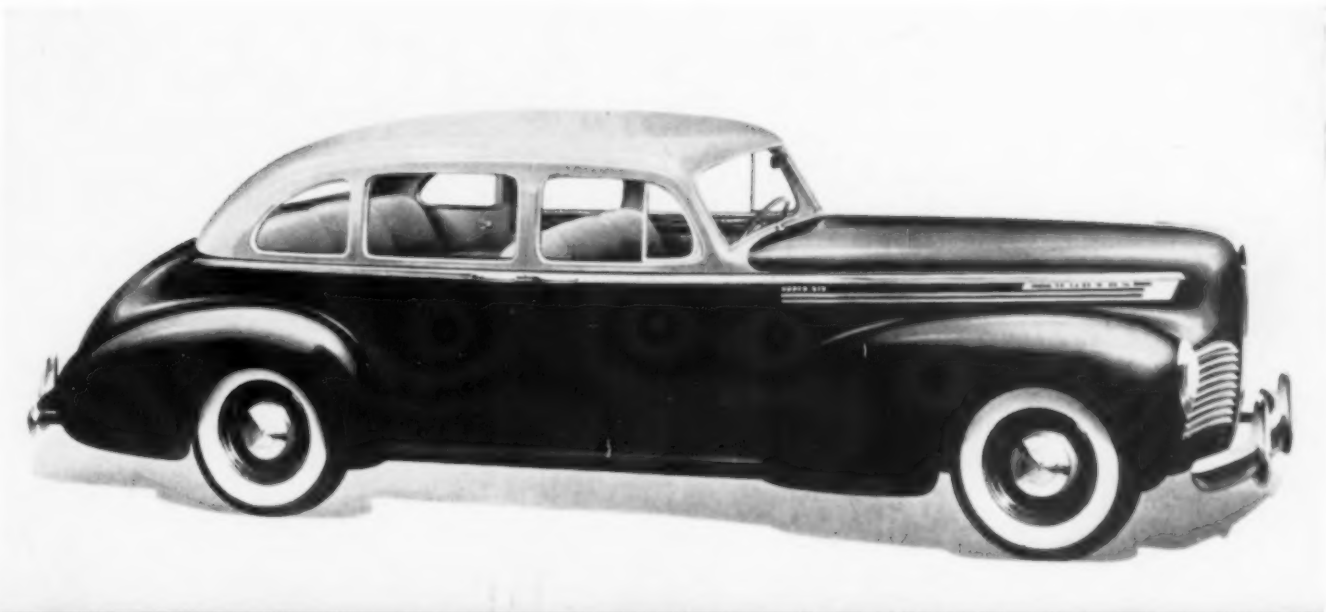
Gerald A. Lux has resigned as technical director at the Lustre Chemical Corp. to accept the American Electroplaters' Society appointment as their research associate at the National Bureau of Standards.

R. M. Terry is now division industrial representative for Shell Oil Co., Inc., with headquarters in Hartford, Conn.

Walter G. Bain is taking one year's extended active duty as first lieutenant in the Air Corps at Wright Field, Dayton, Ohio, where he is assigned to the production engineering section.

TIMKEN *Alloy Steels*

FOR AUTOMOBILES



TIMKEN Alloy Steel is used in gears, pinions, steering arms, support arms, studs, piston pins, king pins and transmission shafts of 1941 Hudson Cars.

The same high quality TIMKEN Alloy Steels that are used in the manufacture of TIMKEN bearings are being used more widely every year in the manufacture of vital parts for automobiles.

TIMKEN GOOD WILL BASED ON GOOD STEEL STEEL

Manufacturers of TIMKEN Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; TIMKEN Alloy Steels and Carbon and Alloy Seamless Tubing, and TIMKEN Rock Bits.

TIMKEN
ALLOY STEELS

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO
Steel and Tube Division

Personals

E. R. Mertz has been appointed teaching specialist in forge practice in the mechanical engineering department of Stanford University, Calif.

William Robert Phillips is now metallurgist for the American Steel Castings Co., Newark, N. J.

Promoted: **Corbin T. Eddy**, from associate professor in the department of metallurgy and mineral dressing, to professor and head of the department of metallurgical engineering, Michigan College of Mining and Technology, Houghton, Mich.

James A. Gates, general foreman at Central Furnaces and Docks, American Steel and Wire Co., has been appointed superintendent.

An
Acknowledgment

We wish to express our appreciation of the endorsement given Wheelco controllers by the recent introduction of a competitive instrument employing the electronic principle.

Wheelco Instruments Company pioneered "Radio Principle" controllers. Its efforts to impress the superiority of this method of control have been amply rewarded by the widespread use of Capacitrols, Potentio-trols, Limitrols, and Therm-otrols. Thousands of these controllers are now in use. The large number of re-orders from companies which early recognized the unusual sensitivity and accuracy inherent in electronic type controllers is indeed gratifying.

The pleasure given us by the enthusiastic acceptance of our equipment for all types of industrial applications is now enhanced by the adoption of our principles in competitive equipment. This verification of our repeated assertion that electronic principles provide the means for revolutionizing the instrument industry prompts us to predict that, in the next few years, all instrument companies will follow the lead set by this company. And, as before, Wheelco will be the pioneer in developing new ways of satisfying industry's requirements.

WHEELCO INSTRUMENTS CO.
1933 South Halsted Street Chicago, Illinois

Transferred by American Steel & Wire Co.: **Elmer E. Legge**, from district director of research in Worcester, Mass., to assistant director of research in Cleveland; **Leonard F. Peskin**, from engineer in charge of transmission in Worcester to technical engineer in Cleveland.

Anthony William Deller, patent attorney and lecturer on patent law at Columbia University's School of Engineering, has been named patent counsel for The International Nickel Co.

R. W. Harris, formerly with Vanadium-Alloys Steel Co., is now with Rustless Iron and Steel Corp. as district manager for Northern Ohio.

Edward Trela is now metallurgist, National Smelting Co., Cleveland.

Robert H. Perry, formerly with Brown Instrument Co., is now sales engineer for the Ajax Electric Co., Inc., in Buffalo.

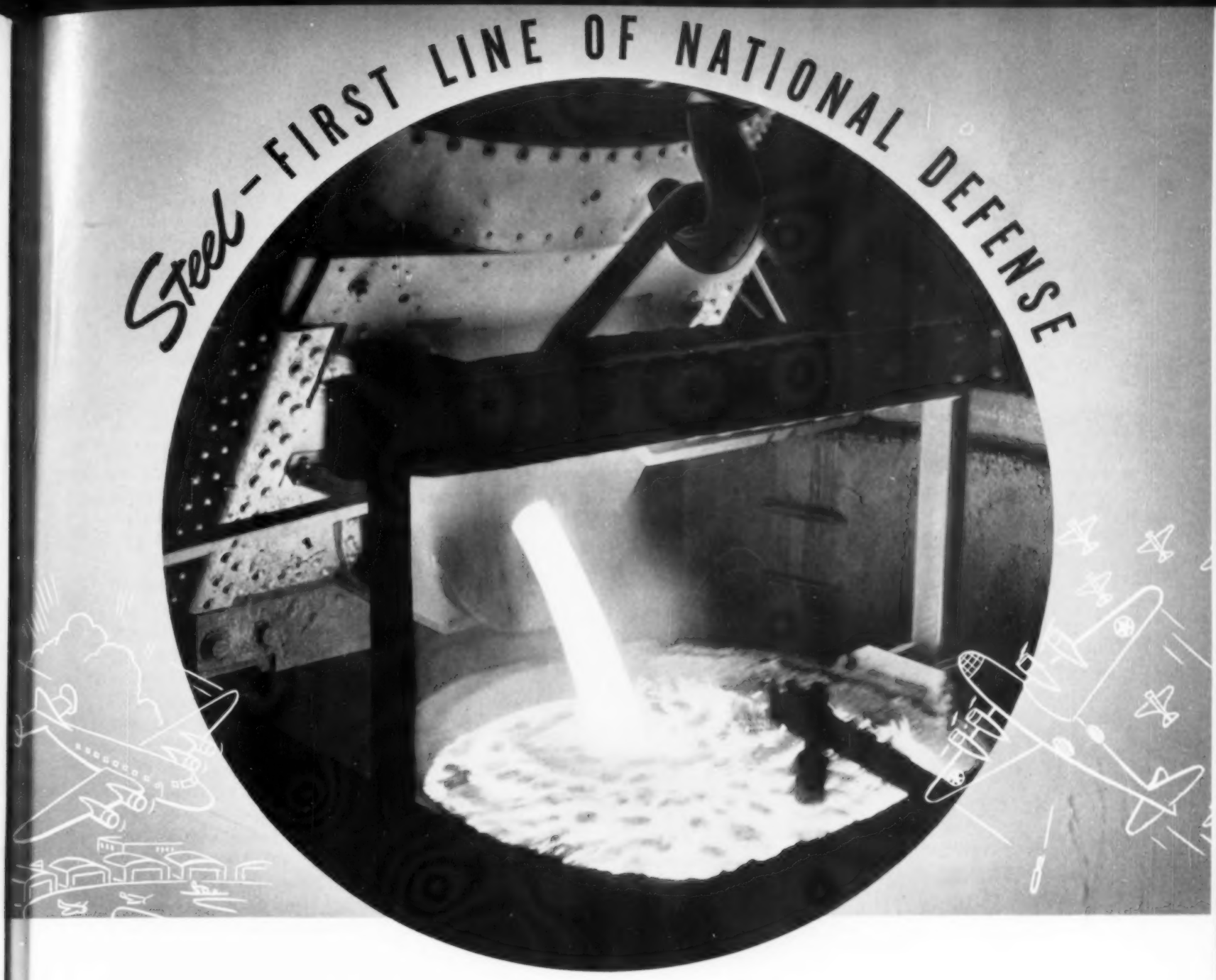
John J. Toth, formerly general superintendent of H. & B. American Machine Co. of Pawtucket, R.I., is now staff engineer with Stevenson, Jordan and Harrison, management engineers of New York City.

John Welchner, formerly metallurgist in charge of laboratory and heat treating at the Wisconsin Axle Division of Timken-Detroit Axle Co., and more recently graduate student at University of Michigan, is now with the Steel and Tube Division of Timken Roller Bearing Co.

R. C. Gubbins is enrolled in the student sales training program at Allegheny Ludlum Steel Corp., Brackenridge, Pa.

George E. Woodger is working in the gear inspection department at Pratt & Whitney Aircraft Division, East Hartford, Conn.

Henry L. Setz is now employed in the inspection department of the Naval Aircraft Factory, Philadelphia.



Republic—World's Largest Producer of "Aircraft Quality" Steels

The Liberty motor, product of the world's most skillful engine designers and the ultimate in aeronautical power plants in 1918, was made possible by the pioneer "aircraft quality" steels that poured from Republic's electric furnaces.

Much research preceded these steels—because Republic, through research, already had become the largest producer of fine alloy steels for the automotive, railroad, petroleum and other industries.

Since then, in close cooperation with Army, Navy and civilian aeronautical engineers, Republic has continued the development of steels for aircraft. Now, with this priceless experience and with an organization thoroughly familiar with aircraft requirements, Republic is the world's largest producer of "aircraft quality" steels.

Today, every American-made plane contains "aircraft quality" steels produced by Republic.

During the last few years, Republic has more than doubled its electric furnace capacity. More than this, Republic has expanded all its facilities—from ore reserves to finishing equipment—and now pledges its huge plants, and its fifty-odd thousand men who know steel, to serving those industries so vital to the safety of America—with steel—first line of national defense.

The line of steels and steel products manufactured by Republic is so diversified that we have prepared a complete listing in Booklet No. 199. A copy will be sent you upon request.

REPUBLIC STEEL CORPORATION • CLEVELAND, OHIO

Berger Manufacturing Division • Niles Steel Products Division • Steel and Tubes Division • Union Drawn Steel Division • Truscon Steel Company

New Magnets

(Continued from page 284)

Since the effective resistance of a coil due to eddy current losses in its core depends on the average particle diameter, it can be decreased when desired by using finely pulverized material.

The problem of insulating 2-81 molybdenum-permalloy powder is to coat the particles with a minimum thickness of a material which will not break away during the pressing operation, which will not fuse and flux the magnetic particles together during the core heat treatment, which will prevent the flow of eddy currents between metallic particles, and which will be chemically inert throughout. The difficulty of the problem will be appreciated from the fact that the separation between adjacent particles of a core of 125 permeability — a much used value — is approximately equal to the wave length of blue light (0.5 micron or 0.00002 in.)

A new type of ceramic insulation has been introduced with these cores which fulfills the above requirements. It is more inert and is free from water soluble residue, and thus eliminates the final washing required by the earlier type.

For applications where a low permeability is desired, non-magnetic powder is added to dilute further the magnetic material. The permeability of the finished core depends largely on the quantity, particle size, and thoroughness of admixture of non-magnetic powder.

A pressure of 100 tons per sq.in. is employed in forming molybdenum-permalloy cores, to attain proper density and mechanical strength. The tensile strength of diluted cores is decreased somewhat from that of undiluted 2-81 permalloy; for example, cores with 25% non-magnetic materials have a tensile strength of about 250 psi.

In annealing the compressed cores to remove strains incident to pressing, it has been found that the insulating material remains intact at a considerably higher temperature if oxygen is excluded. An improved annealing treatment has therefore been introduced by which the cores are heated in an atmosphere of hydrogen, with the attainment of high core permeability and low hysteresis loss. The ability of the insulating material to withstand such a heat treatment testifies to its extreme stability and recommends it in preference to organic materials.

An essential core requirement of precision inductance coils is that the permeability remain unaltered during the life of the coil. The greatest difficulty with cores having no air gaps is the large and more or less permanent shift of permeability due to accidental strong

Does Your Insulation Investment Pay a *FULL* Return?

This Surface-Combustion Soaking Pit, recently installed in the Pittsburgh district, is insulated with 12" x 36" J-M Superex Blocks (shown above) and with JM-20 and Sil-O-Cel C-22 Brick.

HOW much money you spend on fuel depends to a large extent on the answers to these two questions:

Are you using the *correct insulating materials?*

Are they applied in the *correct thicknesses?*

To assure every saving possible with insulation, it will pay you to call in a J-M Insulation Engineer. Let him study your requirements . . . his specialized technical training and experience will help you trace down and correct sources of heat waste that may otherwise go unnoticed.

From the complete line of J-M Insulations, he can recommend exactly the *material* you need for greatest efficiency . . . exactly the *thickness* you need for maximum returns on your investment.

For full details on this helpful service and facts about the complete line of J-M Industrial Insulations, write to Johns-Manville, 22 East 40th Street, New York, N. Y.

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INDUSTRIAL INSULATIONS FOR EVERY TEMPERATURE ... FOR EVERY SERVICE

Superex ... 85% Magnesia ... JM-20 Brick ... Sil-O-Cel C-22 Brick ... Sil-O-Cel Natural Brick ... J-M No. 500 Cement ... Sil-O-Cel C-3 Concrete ... Marinite

magnetization. Such variations have recently been overcome, to a degree, in continuous cores made of hard-rolled nickel-iron alloy sheet, but they have been found to be rather large immediately after strong magnetization, decreasing slowly to tolerable limits only after two or three days. With compressed powdered molybdenum-permalloy cores, permeability shift due to strong magnetization is remarkably small (less than 0.2%) even within a fraction of a minute after the magnetization is released, and any further drift of permeability with time is negligible.

A new requirement for cores has been introduced by quartz crystal filters used in wide-band carrier systems. In order to secure the necessary precision in this type of filter, measures have to be taken to prevent departures from the initial frequency adjustment due to changes in core permeability ordinarily occurring with changing room temperatures. Extremely small temperature coefficients of permeability have now been achieved by adding to the new 2-81 molybdenum-permalloy powder a very small percentage of special permalloy powder having a molybdenum content of about 12%. The latter alloy has a non-magnetic or Curie point close to room temperature and, for a small temperature range just below its Curie point, a negative temperature coefficient several hundred times as large as the positive coefficient of 2-81 molybdenum-permalloy. By choosing suitable compositions and percentages of such compensating alloys, the net temperature coefficient of permeability of a core can be adjusted to any reasonable value, positive or negative, over a desired temperature range. For instance, one "stabilized mixture" has permeability constant to within ± 0.02% between 48 and 105° F.

Greatest immediate benefit to the telephone plant is had by making new coils give the same performance as the old. When this is done the volume required for a single coil on a small exchange area is 1.5 cu.in. instead of 2.5, and the weight is 0.2 lb. instead of 0.4 lb. A difficult problem in the development of winding machinery was involved because of the small dimensions of the hole in the finished coil. Coils for program circuits are larger, 4.4 cu.in. (old style 11.8 cu.in.) and weigh 0.6 lb. It is now practicable to enclose as many as six of these coils directly in the cable splice at a loading point. This dispenses with the need for conventional cases, and reduces both manufacturing and installation costs. The reduction in size is of particular importance in larger cities where underground vault space is at a premium.

. . . always specify Seamless Steel Cylinder Caps and Seamless Steel Neck Rings made by The Pressed Steel Company.

Since 1922 these products have been proving their ability to protect the valves on millions of cylinders throughout the world. They are made of seamless drawn steel. They are light in weight, accurately threaded with any standard thread, and made to fit any type of cylinder.

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THE PRESSED STEEL COMPANY

WILKES-BARRE • PENNSYLVANIA

Soft Soldering

(Continued from page 290)

solders, various high melting point solders have been developed. As a rule, they do not "tin" the metal readily, and some lack mechanical strength. Special solders have also been developed for low temperature work and for chemical resistance to corrosive gases or liquids.

Flux — The main purpose of the flux is to dissolve the oxide film and to protect the hot surface till the molten solder can wet and unite with the metal ("tin" it). The flux should melt before the solder and be sufficiently fluid to flow into the joint.

Two general classes of flux are used: *(a)* Actively corrosive fluxes like zinc chloride or a mixture of zinc chloride and ammonium chloride, and *(b)* "non-corrosive" fluxes like resin, tallow or olive oil. Three parts $ZnCl_2$ to one part NH_4Cl forms a very efficient flux which melts at 355° F. Zinc chloride alone melts at 505° F.

For electrical work, especially in soldering fine wire, corrosive fluxes are not permissible, though where the work can be wiped clean after soldering an intermediate flux consisting of a jelly containing a small proportion of zinc chloride is often used.

Resin (or its solution in alcohol) is better suited to soldering with the copper bit rather than the flame, as the solder is carried mechanically along the joint by the soldering bit. With active zinc chloride fluxes the solder may be applied at a point and will spread freely over and into the joint. This is a real advantage where the work is heated by flame or resistance heating and the solder applied cold.

Tools and Methods — Soldering of aluminum exemplifies the value of the mechanical action of the copper soldering bit. Aluminum forms an oxide which is not easily reduced by any flux. The soldering iron, rubbed over the work, breaks the film and rubs the solder over before new oxide is formed.

Even though large-scale production has developed new methods of heating, the copper soldering "iron" remains a very common and indispensable tool. For continuous production it is electrically heated.

Dipping the work into a solder bath is readily done automatically on a conveyor line. Certain parts of the surface may be protected by a removable shield or a coating of lime wash. Small armatures for automobile self starters are usually soldered by a quick dip.

Where large masses are to be heated the blowpipe is invaluable. It should be remembered,

1431 NATIONALLY KNOWN MANUFACTURERS USE AMPCO METAL FOR DIFFICULT SERVICES...

–Let's LOOK INTO IT FOR OUR PRODUCTS

The increasing preference for Ampco Metal for highly stressed service parts is convincing evidence of its inherent superiority over most non-ferrous alloys. . . . Time and again, Ampco Metal has proved its extraordinary wear resistance — its strength and shock-proof qualities — its ability to often outwear hardened steel—in applications including gears, bushings, bearings, nuts, cams, shifters, thrust plates, forming and drawing dies.

You probably have a place for Ampco Metal in one or more of your products. Why not check with us. Send for data on Ampco Metal and its uses in modern industry.

AMPCO METAL, INC., Dept. MP-9, Milwaukee, Wis.

however, that a flame oxidizes the surface, so that an efficient reducing flux is desirable. Sometimes small parts may be assembled on a conveyor with a definite length of solder wire and passed through a series of flames.

Electrical resistance heating is also an efficient production operation. Direct internal resistance to a current imposed by a spot or butt welder can be used, but more frequently carbon terminals are clamped against the joint and these terminals generate most of the heat. [The method and equipment are described at length in METAL PROGRESS for September, 1930, page 54.] The solder is applied cold, usually in the form of flux cored wire, and it is then melted by the heat of the part being soldered.

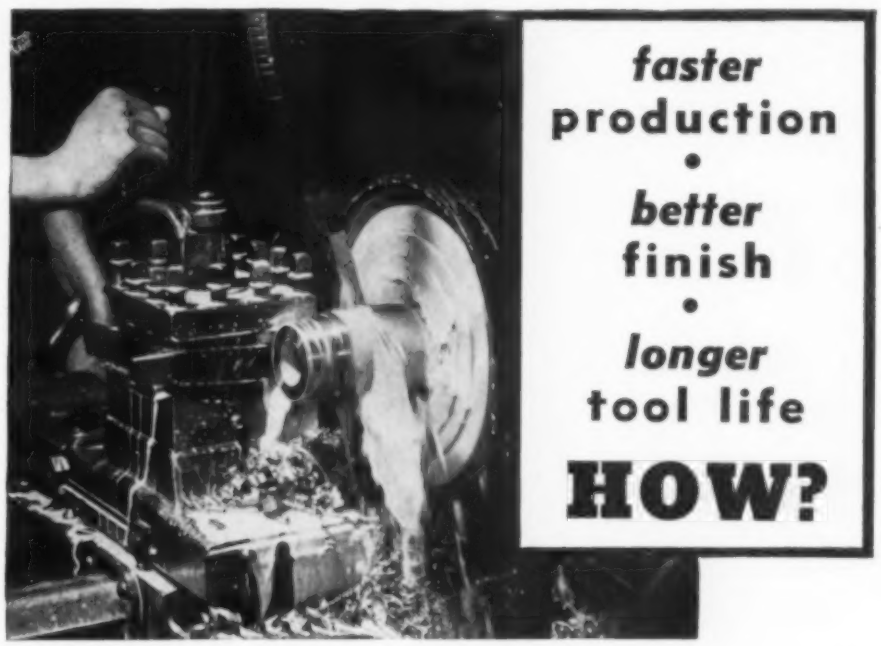
This method has several advantages: *(a)* It insures that the work has been heated to the melting point of solder or beyond it; *(b)* the heating time may be reduced by larger currents; *(c)* the heat can be closely localized; *(d)* it can be used where neither flame nor soldering iron is effective; *(e)* there is less oxidation of the metal surfaces.

Common examples of this work are the soldering of terminals to electrical conductors, battery lugs to cables, fixing of drilled terminal screws, and metal-to-metal connections in contact with plastics or insulation which must not be heated.

Copper brazing in a continuous furnace with a hydrogen atmosphere has been so successful that attempts have been made to adapt it to soldering. Unfortunately, hydrogen has little reducing value at soft soldering temperatures, so an active flux must be employed.

Strength of soldered joints is low, about 6000 to 8000 psi. in a tensile test and 4000 to 6000 psi. in a shear test, the lead-rich solders being weaker than the tin-rich. Antimony increases the tensile strength, the shear strength and the hardness, but makes the joint more brittle and decreases the electrical conductivity, which at best is only about 10% that of copper.

Strength figures must be discounted by 10% if the joint is to operate at 200° F., and 50% if at 300° F. It must also be remembered that the size of the gap has an appreciable effect on the strength of the resultant joint, and that in soft soldering the flux must precede the molten solder into the joint. For small gaps a free flowing flux and solder are necessary. For the strengths already referred to, gaps are from 0.003 to 0.006 in. In dipping the minimum gap which will allow the solder to flow readily without flux or air inclusions is about 0.010 in. In dipped joints capillary attraction holds the solder to about 0.030 in. of gap.



If these are problems that concern you, why not let our lubrication engineers help you solve them with the right cutting fluid? They have done that for others. They can do it for you!

One prominent screw manufacturer*, for instance, was thus able to step-up production, lengthen tool life and turn out better finished work than he was able to do previously.

Cities Service Metal Cutting lubricants are made to meet the exacting needs of modern industry by specialists conversant with every phase of metal cutting lubrication. Let us get acquainted for mutual profit.

Copies of our booklet on "Metal Cutting Lubrication" are still available to users of cutting fluids. Write for your copy—today—before the supply is exhausted.

* *Name furnished on request.*

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Please send me information concerning your Lubrication Engineers' Service ☐

Please send me booklet on Metal Cutting Lubrication ☐

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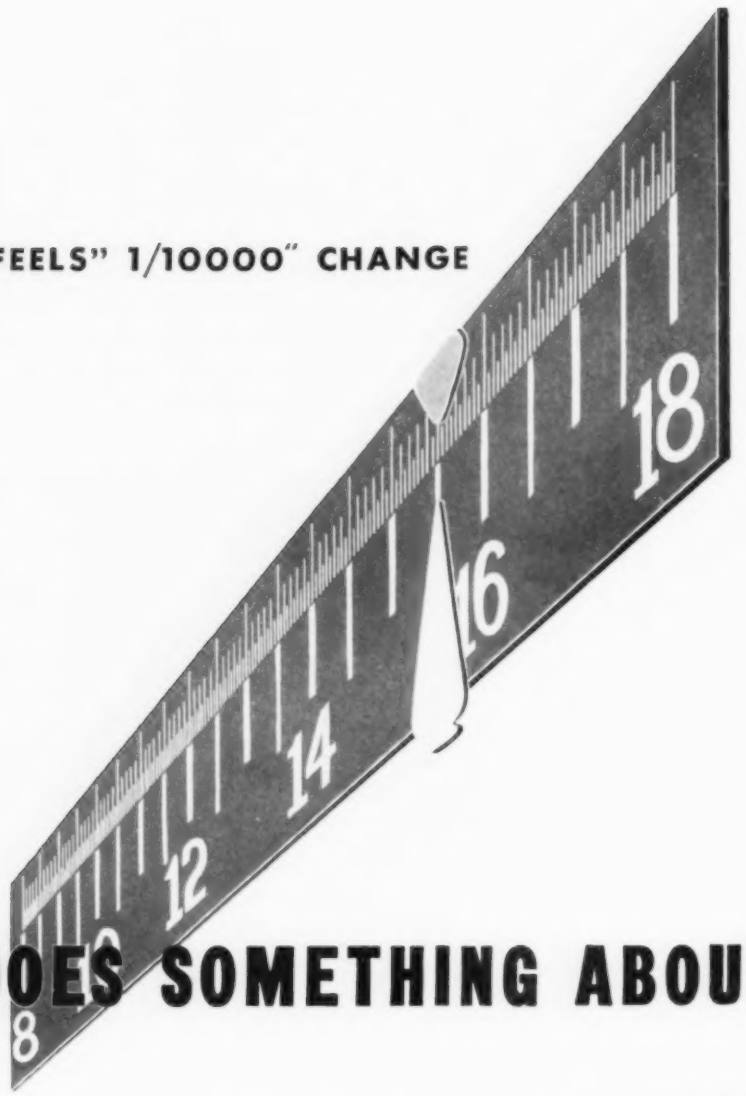
Firm Name .....

City ..... *State* .....



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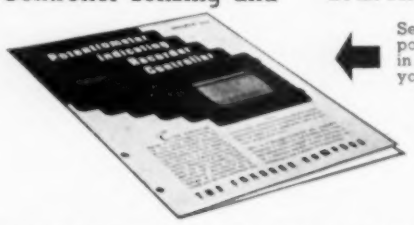
How better could the accuracy and sensitivity of a Foxboro Indicating Recorder-Controller be expressed? A pointer deflection of .0001" results in an appreciable change in pen position and control action. There are no "dead spots," no lost motion.

Dependable, accurate performance of a control instrument is absolutely essential – otherwise why depend upon instruments at all? As pioneers in the design and perfection of control instruments, Foxboro incorporates in this Recording Controller sensing and control mechanisms which assure a degree of sensitivity and accuracy unheard of in former instruments.

Among those companies where a close check of instrument performance is maintained the Foxboro Recorder-Controller has been generally adopted for new installations. It will pay you to "look into" the mechanical features which have enabled these instruments to establish new operating standards. **The Foxboro Company, 52 Neponset Ave., Foxboro, Mass., U. S. A.** Branch Offices in 25 cities.

Foxboro Indicating Recorder-Controller
Three Types:
Electric 2-Position Control
Electric Throttling Control
Stabilog Air-Operated Throttling Control



Send for Bulletin 240 – it points out developments in control instrumentation you can't afford to miss.

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DO YOU HAVE SUFFICIENT TEMPERING CAPACITY?

Is production being slowed down in your plant due to inadequate tempering furnace equipment? If so, now is the time for the Cyclone Tempering Furnace to move in and blast the jams out of your production line, as it is doing for thousands of other heat treaters.

. . .

You see, the Cyclone didn't become industry's favorite tempering furnace by accident. Just a squint into the work chamber of the Cyclone will convince you that chance had nothing to do with it, for the Cyclone was *designed* to be the husky brute that it is, and has *proven* that it can stand up under all the abuse that anybody could give it without wincing or faltering for a single instant. And, in addition to its ability to stand up on the production line and handle the heaviest loads you can pile into it day after day, 24 hours a day, the Cyclone gives you *laboratory heating accuracy*. So whether or not you are faced with the toughest government or private specifications being written today, you can relax the frown the day the Cyclone moves into your plant, for the Cyclone takes those plus or minus 1-point Rockwell "C" specifications without batting an eye.

Put the Cyclone to work and watch those production jams disappear. Catalogue on request, or contact the nearest district office.

LINDBERG ENGINEERING COMPANY
222 North Laflin Street Chicago

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HOT DIP
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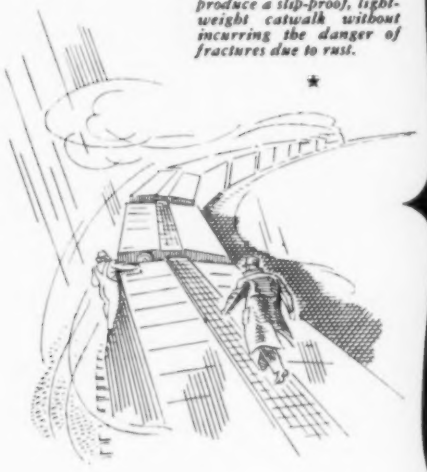
solves another problem



THE PROBLEM . . . To produce a slip-proof, lightweight catwalk without incurring the danger of fractures due to rust.

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★ *THE ANSWER . . . A Hot Dip Galvanized Open Steel Running Board.*

38 RAILROADS HAVE ALREADY SAID, "YES"

Where rust is a factor and excess weight a disadvantage, manufacturers often find that they can safely reduce the size of iron and steel parts by specifying genuine Hot Dip Galvanizing. Hot Dip Galvanizing guarantees maximum rust protection at minimum cost. It means an adequately thick coating of zinc and a union between zinc coating and base metal that makes each an inseparable part of the other. There is no *safe* substitute for genuine Hot Dip Galvanizing. Patronize our members and know that you are getting only this quality type of work. Write for literature. American Hot Dip Galvanizers Association, Inc., American Bank Bldg., Pittsburgh, Pa.

IF IT CARRIES THIS SEAL IT'S A JOB WELL DONE

Acme Galvanizing, Inc., Milwaukee, Wis. ★ Acme Steel & Malleable Iron Works, Buffalo, N. Y. ★ American Tinning & Galvanizing Co., Erie, Pa. ★ Atlantic Steel Company, Atlanta, Georgia ★ Buffalo Galvanizing & Tinning Wks., Inc., Buffalo, N. Y. ★ Diamond Expansion Bolt Co., Inc., Garwood, N. J. ★ The Fanner Mfg. Company, Cleveland, Ohio ★ John Finn Metal Works, San Francisco, Cal. ★ Thomas Gregory Galvanizing Works, Maspeth, N. Y. ★ Hanlon-Gregory Galvanizing Co., Pittsburgh, Pa. ★ Hubbard & Co., Oakland, Cal. ★ Independent Galvanizing Co., Newark, N. J. ★ International Derrick & Equipment Co., Columbus, O. ★ Joslyn Co. of California, Los Angeles, Cal. ★ Joslyn Mfg. & Supply Co., Chicago, Ill. ★ L. O. Koven & Brother, Inc., Jersey City, N. J. ★ Lehigh Structural Steel Co., Allentown, Pa. ★ Lewis Bolt & Nut Company, Minneapolis, Minn. ★ Missouri Rolling Mill Corp., St. Louis, Mo. ★ The National Telephone Supply Co., Cleveland, Ohio ★ Riverside Foundry & Galvanizing Co., Kalamazoo, Mich. ★ San Francisco Galvanizing Works, San Francisco, Cal. ★ The Sanitary Tinning Co., Cleveland, O. ★ Standard Galvanizing Co., Chicago, Ill. ★ Wilcox, Crittenden & Co., Inc., Middletown, Conn. ★ The Witt Cornice Co., Cincinnati, O.

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SPEED CASE STEEL Increased Production On These Parts 47% to 100%

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S. A. E. x 1020 — 51 per hour
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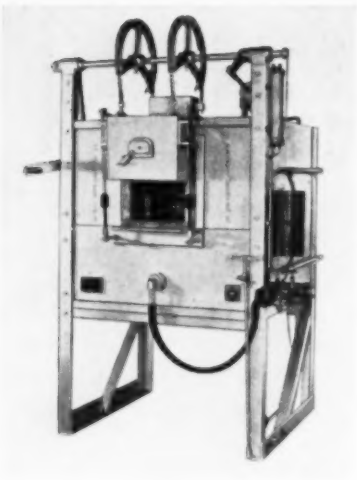
STANDARD TOOLS | CUSTOM TOOLS AND DIES | SPECIAL PARTS

STUDY THESE 4 DISTINCT BENEFITS OF "CERTAIN CURTAIN" PRECISION ATMOSPHERE CONTROL



1. MAXIMUM WORKING LIFE, developed in all types of tool steel. In our patented controlled-atmosphere furnaces, work is fully protected from surface attack while holding amply long to develop the maximum working qualities of the steel.

2. MAXIMUM PRODUCTION. Increased production in the heat-treating department, per furnace per man, is a usual result. Savings up to 50% not uncommon.

3. MAXIMUM YIELD, or to put it another way, Minimum Spoilage. Makers of standard tools have experienced major savings through eliminating spoilage, while on custom tools and dies the certainty of results is of immense benefit.

4. MAXIMUM PROFIT. Investment in "Certain Curtain" furnaces returns an amazingly high profit on the capital involved, customarily earning back their cost in 6 to 17 months, on an average of a little less than a year.

For every heat-treating process involving atmosphere control, the "Certain Curtain" line provides furnaces assuring MAXIMUM results! Catalogs upon request.

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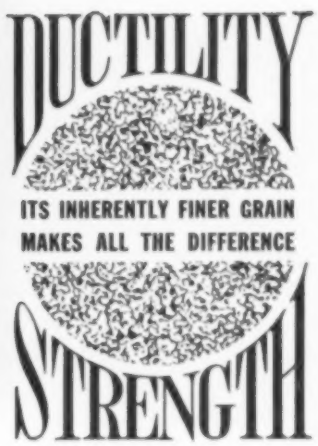
NOW . . . an advanced High Tensile Steel for light-weight high speed trains . . .

N-A-X

High Tensile

. . . EQUIPMENT WILL HAVE GREATER RESISTANCE TO IMPACT AND FATIGUE, AT BOTH NORMAL AND EXTREMELY LOW TEMPERATURES



N-A-X HIGH TENSILE is a high tensile low alloy steel with unusual resistance to impact and fatigue—properties that keep rolling equipment on the job, regardless of operating or weather conditions, year in and year out.

Car builders like N-A-X HIGH TENSILE, for usually there are no shop change-overs required for fabrication. It can be cold formed easily and welded by any of the standard practices used for mild steel.

N-A-X HIGH TENSILE has other valuable properties, too, which aid materially in extending the service life of rolling stock. They are: Unusual ductility, high yield point and ultimate strength, excellent resistance to corrosion and abrasion, extremely high resistance to impact and fatigue, at normal as well as at sub-zero temperatures.

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A Great Lakes engineer is available at any time to talk over your designs or to give you additional information about the application of N-A-X HIGH TENSILE in your equipment. Wire, write or telephone for one to call. No obligation. Great Lakes Steel Corporation, Detroit, Mich.

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Boston, 1324 Statler Office Building; *Buffalo*, 1000 Walbridge Building; *Chattanooga*, 18 Volunteer Building; *Chicago*, 1026 Builders Building; *Cleveland*, 820 Leader Building; *Dayton*, 1401 Third National Bank Building; *Indianapolis*, 1215-17 Circle Tower; *Minneapolis*, 714 Midland Bank Building; *New York*, 405 Lexington Avenue; *Philadelphia*, 407 Liberty Trust Building; *St. Louis*, 3615 Olive Street; *San Francisco*, 824 Sharon Building; *Toledo*, 906 Edison Building. *Montreal, Quebec*, Drummond, McCall & Co., Limited; *Toronto, Ontario*, Peckover's, Limited.

division of NATIONAL STEEL CORPORATION

Executive Offices, Pittsburgh, Pa.

Notes About Contributors

John F. Wyzalek, who calls himself a practical metallurgist, started with Hyatt Bearings Division of General Motors Corp. in 1913. Five years later at the age of 23 he was made chief metallurgist, the position he has held ever since. Needless to say, he grew up with the heat treating industry, watching (and helping) the art of casehardening mature to a science. Wyzalek's activities extend beyond his own organization, however; particularly noteworthy is his extra-curricular work as charter member and a past chairman of the New Jersey Chapter, and past member of the Constitution and By-Laws Committee of the national Society. He is also active in A.S.T.M. committee work and a member of the American Iron and Steel Institute.

Junior Author **M. H. Folkner** came to Hyatt Bearings Division from Lehigh University in 1935 with a B.S. in metallurgical engineering. He devotes his time primarily to metallurgical development work.

About 20 years ago, *Metallurgical and Chemical Engineering* (the McGraw-Hill magazine) was served by ELLWOOD HENDRICK as consulting editor. HENDRICK — God rest his gentle soul! — had owned and sold profitably one of the pioneer plants of the American chemical industry; hence the consulting editorship. A scion of a family whose roots go back to Niew Amsterdam, and member of that still-famous organization The Dutch Treat Club, he corresponded regularly with the intelligentsia of the Low Countries. Among these scientists and philosophers was **Martin Seyt,** whose letters on matters metallurgical were deemed worthy of publication. As one of the spiritual heirs of ELLWOOD HENDRICK, the editor of METAL PROGRESS has fostered this interchange of letters, as constant readers of this magazine will recall, and in response to a request for a portrait and biographical article **Seyt** merely sent his jolly profile set against a cubistic background. Perhaps "futuristic" would be a better description of this portrait, in view of the wings branching sidewise, and of the envelope post-marked Rotterdam.

Six years ago **Matthew Charlton,** author of the paper on page 287 about the sudden change in workability of commercially pure iron well up in a range ordinarily thought to be very ductile, was graduated as Bachelor of Science in Metallurgy from Case School of Applied Science in Cleveland. Despite the depression he caught on as junior metallurgist at Timken Steel and Tube in Canton, and after two years went to Youngstown as laboratory foreman at the Ohio Works, Carnegie-Illinois Steel Co. A couple of months ago he resigned to become assistant heat treat foreman for Detroit Transmission Division of General Motors.

A camera bug who had a good idea and the talent to carry it through is **Van Fisher,** whose pictorial stories have been a regular feature of METAL PROGRESS for the past four years. With a $30 second-hand camera for equipment he worked his way through University of Wisconsin, and in 1935 set up in business in Cleveland. METAL PROGRESS gave him his first opportunity to do the big industrial stories he visualized, which in 1939 brought home *Industrial Marketing's* blue ribbon in this field of journalism. About a year ago Mr. Fisher decided to seek wider fields and is now free-lancing in New York.

John F. Wyzalek

Bachrach

M. H. Folkner

Van Fisher

Martin Seyt

The 8-STEEL Tool kit

does the job easier, cheaper, better

BETHLEHEM'S set of 8 service-proved tool steels is all you need to operate your shop efficiently and profitably—regardless of the type of metal work you handle.

These steels are old standbys. Each one has earned its reputation the hard way—in big and small machine shops all over America. By standardizing on these 8 top-notch steels you reduce inventory, simplify heat-treatment. Furthermore, you'll become so familiar with the capabilities of these steels that you can cut operating costs and increase the quality of your product at the same time.

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XCL	RED TIGER	LEHIGH DIE & TOOL
SPECIAL HIGH SPEED	NO. 57 HOT WORK	TOOL ROOM
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TO PRODUCE CASTINGS WITH CLEAN SURFACES

TAM Foundry Zirconite Sands in two grades, "A" and "B" (differing chiefly in melting points) are fine grain core and mold sands ready for use by the foundry. They possess high resistance to "burn in" and yield castings which clean rapidly and require but little subsequent work in the chipping and cleaning department.

TAM Foundry Zirconite Flours in two grades, "A" and "B" (differing chiefly in melting points) are core and mold wash materials to be prepared by the foundry. They supersede ordinary flours, such as Silica, and ordinary foundry sands that have a tendency to "burn in", with resultant roughness and high cleaning costs. Mold or core washes made up of TAM Foundry Zirconite Flours plus a bond and suspension medium can be either sprayed, swabbed or brushed on.

TAM Zirconite Core and Mold Washes in two grades, "A" and "B" (differing chiefly in melting points) are *super-refractory*, materials designed for mold and core washes where high resistance to "burn in" is desired. Ease of mixing (just add the material to water) and simplicity of application by either spraying, swabbing or painting, makes the use of TAM Zirconite Mold Washes an exceptionally efficient foundry practice.

THE MERIT MARK OF METAL — TAM METALLURGICAL ALLOYS

● *Full specifications and recommended uses of TAM Zirconite Materials for the steel, malleable and gray cast iron molder will be sent promptly on request. Or, if desired, a TAM representative will call at your plant.*

Titanium

ALLOY MANUFACTURING COMPANY

NIAGARA FALLS, N. Y.

Copper Alloys in Refineries

By James T. Kemp

THE PROBLEM of corrosion in the oil refinery has been intensified in recent years from changes in both the crude oil supply and methods of refining. Production of corrosive high sulphur crudes has increased; high temperature and high pressure liquid and vapor phase cracking is prevalent; temperatures and velocities in heat transfer equipment have been stepped up. These conditions have resulted in much damage to the brass and bronze equipment used so extensively, and warranted a series of papers at the May 29 meeting of the American Petroleum Institute. Of these, one by Mr. KEMP will be abstracted.

Refiners use the copper alloys principally for tubes and tube sheets in heat exchangers and condensers; for baffle and turbulence plates; for pipe for conveying dilute acid and the residues from acid treatments; for water supply systems; and for many other purposes, including protective linings.

Admiralty (70-30 brass plus 1% tin) condenser and heat exchanger tubes comprised 78% of all U.S. refinery purchases in 1939. One-tenth as much red brass was bought. Aluminum brass as yet has not been adopted to a very great extent by American seaboard refineries using sea and bay water; in this respect these refineries have lagged behind their brethren abroad, in power stations at home, and on the sea. Cupro-nickels comprised 10% of the 1939 purchases; usually the 30% nickel alloy is installed in troublesome places without trial of the 20% alloy which may be good enough.

Generally speaking, little oil-side corrosion is experienced in exchangers heating still feeds, and not much on the other side from run-of-refinery overhead. Cooling water is a refinery problem everywhere; the condensers are one of the sensitive spots. Poor water causes as much tube destruction as the condensing vapors. On the vapor side where steam condenses and water accumulates on the tubes, anything and everything may happen — general wastage, thinning the tube wall, deep pits, dezincification, and cracking. The severity of attack depends on the crudes, under or over-treatment of the vapors with neutralizers, construction of the bundle, flow of gas over the tubes, drainage, cleanliness, and constancy of cooling water supply. Usually the condensate causes little difficulty with brass tubes in submerged condensers. Brass tubes in exchangers on stabilizers, or in shell and tube equipment handling the fixed gases, rarely are corroded to failure by the gas stream.

We do not know why just the proportions of

(Continued on page 338)

PROOF THAT ENDOGAS

HARDENS EVEN S. A. E. 1095 WITH NO DECARBURIZATION

ENDOGAS SCALE-FREE HARDENING SHOWS NO "DECARB" OF S.A.E. 1095

This micro-photograph proves conclusively that no decarburization takes place when S. A. E. 1095 steel is scale-free hardened in the Westinghouse ENDOGAS atmosphere. Treatment was for one hour at 1500° F.

...YET ORDINARY SCALE-FREE HARDENING DECARBURIZES TO .005 INCH

This is what happened to the same steel—S.A.E.1095—when hardened for the same period, at the same temperature, in an ordinary scale-free gas atmosphere. Upper white portion reveals decarburization to approximately .005".

S. A. E. 1095 is just one of many steels considered difficult to treat, which ENDOGAS hardens without a trace of decarburization. Yet ENDOGAS is not expensive—is easily obtained using either natural or manufactured city gas as a base. Costly driers and CO_2 removal equipment are not required.

J-10199

Complete technical data is now available on how to apply this low cost method of hardening and annealing under production conditions. Write for it today and get the jump on competition.

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Thickness of Coatings on Metals
Now Measured Rapidly and Non-destructively

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Measures Thickness of:

Magnetic Coatings on Non-magnetic Base Metals
Non-magnetic Coatings on Magnetic Base Metals
Nickel Coatings on Iron or Steel

RAPID . . . permits testing of a large number of specimens at low cost, with little experience.

UNIVERSAL . . . applicable to plane, convex or concave surfaces.

NON-DESTRUCTIVE . . . will not injure the coating or the base metal, thus effecting great savings.

COMPACT . . . PORTABLE . . . weighs only 7½ lbs. *Ideal for Works Control or Acceptance Testing*

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Sentry sells by comparison

Write today for details or send sample tools for demonstration hardening.

The Sentry Company
FOXBORO, MASS., U.S.A.

Spot Welding Aluminum

(Continued from page 274) in a secondary winding connected to the welding circuit (arms, electrodes and sheets to be welded).

Pressure is also variable and is regulated by a double acting air cylinder in which the piston rod is so large that the force exerted by a given air pressure on the top side *A* of the piston is about twice that on the bottom side *B*. After pressure and current settings are made in accordance with the material being welded, the routine of making a spot weld is as follows:

1. Work is inserted and the starter pushed.

2. The pressure valve is actuated, opening the lower chamber *B* of the cylinder to atmosphere and connecting the top chamber *A* to the compressed air supply, thus applying high initial contact pressure to the work. This brings the areas to be welded into good contact and smooths out any roughness in the sheets.

3. Lower chamber *B* is then connected to the same air supply, decreasing the pressure about one half.

4. The contactor closes, starting the flow of current from the mercury arc rectifier into the transformer, charging its core with energy.

5. At the pre-set maximum, the current relay opens, causing the stored energy to be discharged, the surge being magnified many times in the secondary, and a spot is welded.

6. After reaching a maximum almost instantly, the welding current drops off; during this time the lower chamber is disconnected to the air supply and is again opened to atmosphere. Since the upper chamber is still connected, a pressure equal to the initial contact pressure is again applied to the work. This pressure is applied when the welding current has dropped about halfway back to zero from maximum and is held for a certain period. It comes on while the welded metal is still hot and forges and refines the grain structure of the weld.

7. The lower chamber is then connected to the air supply and the upper chamber opened to atmosphere causing the electrode to open to rest position.

Welding by this process has another highly desirable advantage in that it is possible to weld certain aluminum alloys without carefully cleaning the surfaces. The advantages of welding by the energy storage method are further confirmed by the fact that one American manufacturer has recently put a machine of this type on the market which uses the energy storage principle but accomplishes the results in a different manner.

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GOLD &
SILVER
Plating
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- ★ Readily dissolved in cyanide solutions
- ★ No formation of objectionable and wasteful inert salts
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- ★ Wide range of gold colors

Our nearest district office will be pleased to tell you how du Pont Precious Metal Cyanides can be used to produce desired or popular finishes.

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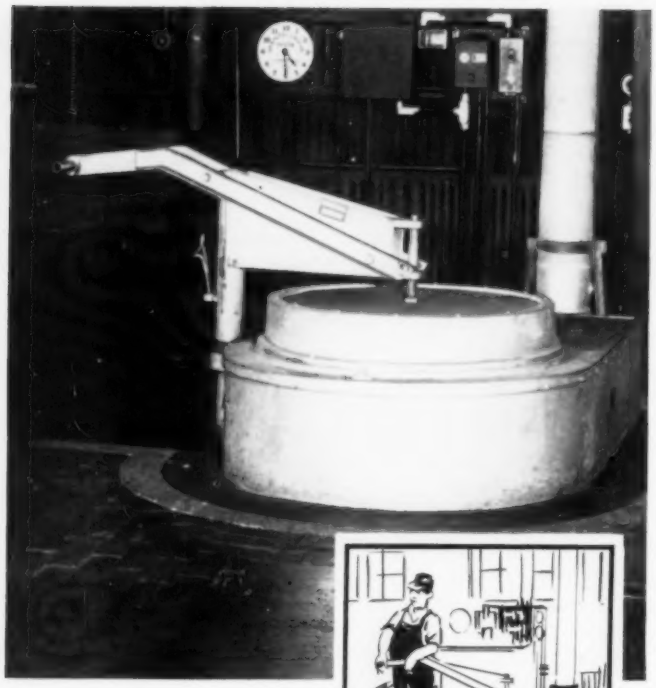
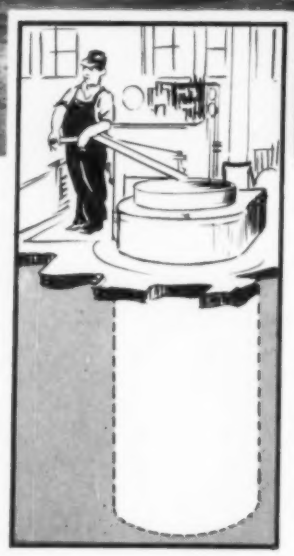
LOOK AT THIS 60" DEEP POT FURNACE





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This furnace should be interesting to manufacturers who must heat treat long shafts, etc. because of its unusual depth.

Other typical Despatch features distinguish this installation. A high capacity, high pressure alloy steel air circulating fan forces the heated air into the bottom of the furnace through special mixing and heat distributing ducts. The heated air is forced to rise vertically through the load and to go over the top of the work basket down along the sides, back into recirculating ducts to be taken back to the heating system for reheating and recirculation.

Cold basket walls are eliminated . . . lower combustion chamber temperature maintained . . . refractory replacements lowered . . . and constant production assured.

Write today for more information about this furnace and other Despatch products, including ovens, dryers, furnaces and air heaters.

DESPATCH OVEN CO.

BUILDERS OF OVENS, DRYERS, FURNACES AND AIR HEATERS

MINNEAPOLIS, MINNESOTA

Copper Alloys in Refineries

(Continued from page 326)

admiralty should be of so much more general serviceability than others, but there has been no substantial change in the composition through years of question and experiment. There is an accepted belief that it affords better resistance to sulphide-chloride corrosion on the gas stream and oil-side than brasses richer in copper, and that it strikes a fair middle of corrosion resistance on the water-side. The weaknesses of admiralty are those of all the brasses of its type, a susceptibility to dezincification and to an intercrystalline type of cracking. Of the two, dezincification is much more frequent, and usually develops on the water-side. Several remedies have been proposed and used. A selected fourth alloying element can be introduced with advantage — at least under standard and observable conditions. Arsenic has been used for this purpose since 1933; more recently antimony and phosphorus have been promoted. The true value of each of these special admiralties will appear as experience is gained in actual service.

Intercrystalline cracking is a subtle phenomenon often caused by unsuspected forces that may originate in bundle assembly, temperature differentials, lack of mechanical freedom of the floating ends, and from poor rolling. It is a very infrequent type of failure. We have never seen a case in which intercrystalline corrosion of admiralty or similar condenser tube alloys was proved to have been due to the presence of any addition element or impurity in the alloy. Corrosion cracking is found, although rarely, even in deoxidized copper, and in many metals and alloys containing no copper. It will be with us so long as bundles are put together as they are today and the control of corrodants and neutralizers remains a matter of manual attention and dependence on the color of the trapped-off water or on acidity determinations made at intervals.

The backs of the tube sheets, the baffles and turbulence plates do not corrode as rapidly as the tubes, in spite of being alloys of lower intrinsic resistance. The lesser attack may be due to lack of temperature difference between the metal and the gas stream. This casts a doubt upon the reliability of observations of test specimens suspended in a gas stream, and tends to emphasize the value of actual service testing. This opinion evidently is held by refinery engineers; one of the important catalytic plants in the East has built small exchangers into the system, parallel to the main condensers, to operate on splits from both gas and cooling water streams. These experimental exchangers can be cut off from the main stream for inspection, or for changing tubes at will.